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Biological Diversity: Global Conservation Needs and Costs*

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BIODIVERSITY: GLOBAL CONSERVATION NEEDS AND COSTS

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the United Nations Environment Programme

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1 INTRODUCTION

1.1 Global Concerns

The Ad-Hoc Working Group of Experts on Biological Diversity of the United Nations Environment Programme [UNEP] met in Geneva on 19-23 February 1990, in connection with its work to prepare a legal instrument or mechanism on the conservation of biological diversity for the planet [UNEP 1990]. It agreed on the following areas representing basic conservation needs, that would lead to measures of implementation and funding through the adoption of the new international legal instrument:

[1] **Survey, inventory, identification and authentication** of biological diversity with reference to rich and threatened areas, conservation technologies and techniques, and to sustainable use technologies and techniques;

[2] **Technical assistance and cooperation** for research, training and education, public awareness campaigns, surveys and inventories, etc. on biological diversity, in particular:

* **Biodiversity Research**: surveys and inventories of species, their ecology and natural history, their systematics and biogeography, and their ethnobiology;

* **Biotic Depositories**: establishment, maintenance, use and servicing of ex-situ and in-situ depositories of biological diversity;

* **Socio-Economic Research**: assessing the benefits and outputs derived from the conservation of biological diversity;

* **Education**: educating senior decision-makers on the importance of biological diversity, and the benefits lost when biodiversity is harmed;

* **Technical Training**: competence in the use of available technologies for the collection, identification, maintenance, monitoring and use of biological diversity;

* **Rights of Indigenous Peoples**; recognition of the rights of indigenous peoples to benefit from their highly practical knowledge of local organisms, incorporating traditional uses of local habitats and ecosystems;

[3] **Management strategies and plans** for conserving biological diversity with particular reference to rich areas, highly endemic areas, threatened areas, areal restoration and recovery, coordination of various conservation activities, networking of protected areas, and the development of national conservation strategies;

[4] **Regular monitoring** of the status of the world's biological diversity;

[5] **Coordination of conservation management strategies and plans** with sustainable development policies;

[6] **Priority conservation projects**;

[7] **Needs of existing international legal instruments** on biological diversity; and

[8] **Transfer of technology**.

Although biological diversity is now viewed as an economically valuable natural resource, the Group noted the considerable difficulties in adequately assessing the total economic value of the benefits of its conservation. The Working Group therefore identified among others the need for a case study on meaningful costing of global conservation needs. These basic conservation needs could be envisaged within the framework of a global strategy for conserving biological strategy.

1.2 Terms of Reference

This case study on the needs and costs of a global strategy for conserving biological diversity was commissioned on the basis of areas of basic conservation needs identified by the Ad-Hoc Working Group of Experts on Biological Diversity [UNEP 1990; see above]. It was given the following terms of reference:

[1] To assess the **cost of a global strategy** for conserving biological diversity over the next 10-20 years;

[2] To itemise separately **each specific cost element** in the strategy for conserving biological diversity in terms of capital costs, operating costs, one-time investment, recurring expenditure, etc.:

2.1 Formation of a **consensus on international priorities** for maintaining biodiversity;

2.2 Provision of a framework for detailed **Regional Action Plans** to stem the loss of biodiversity;

2.3 Realization of opportunities to use the Regional Action Plans to **benefit local and indigenous populations**;

2.4 Development of an **Emergency Action Plan for Protected Areas** for regions that require special attention, and for new Protected Areas needed in the regions that scientists agree have the greatest biodiversity value;

2.5 **Research into the identification, clarification, promotion and sustainable use** of tropical biological resources outside the main band of species now exploited;

2.6 **Research into the ways in which indigenous people harvest useful substances** from tropical wild lands on a sustainable basis; and

2.7 **Cost of obtaining patent protection for new medicines and other chemicals** derived from tropical species in order to overcome the private sector's reluctance to spend money on research in this area.

[3] To present **assumptions and methodology used** in calculating these costs to enable assessment of its reliability;

[4] To consider costs incurred as a result of **delaying development and growth**, and any other indirect costs;

[5] To identify which of these costs can be included for **additional finances or support**, and which should be met locally by governments.

This report on the case study attempts to address these terms of reference, in particular the needs and costs of a global strategy for conserving biological diversity based on the areas identified by the Ad-Hoc Working Group of Experts on Biological Diversity of the United Nations Environment Programme. It follows the outline of these terms of reference.

1.3 Rationale for Conserving Biological Diversity

"**Biological diversity** refers to the variety and variability among living organisms and the ecological complexes in which they occur. **Diversity** can be defined as the number of different items and their relative frequency. For biological diversity, these items are organized at many levels, ranging from complete ecosystems to the chemical structures that are the molecular basis of heredity. Thus, the term encompasses different ecosystems, species, genes, and their relative abundance" [OTA 1987].

Biological diversity constitutes the common heritage of humankind and the capital stock of this planet, the renewable rate of which is the "interest" supporting life especially human life and carrying capacity. It therefore commands a sense of common responsibility for conservation, even though legally it is not commonly owned by all humankind as a property. Biological diversity has never been constant in the history of planet Earth. It has experienced rapid extinction periods at several points in geological history followed by "recovery" in directions that were basically unpredictable and that involved evolutionary processes that promoted greater control and independence in relation to environmental fluctuations. The last major extinction of biological diversity occurred during the Cretaceous Period, about 65 million years ago, when birds and mammals were particularly affected. Biological diversity is currently being lost at an unprecedented rate due to anthropogenic causes. For the first time in geological history, the expansion of human populations and their life-support systems [including technologies], are especially affecting the tropics and the marine environment which contain more than 50% of the species diversity on this planet, and isolated mountains and oceanic islands which have a high degree of endemism. This loss is serious for it potentially threatens human advancement and the sustainability of economic livelihood and prosperity which largely depend on the utilization of biological resources and ecological processes, and take advantage of the properties of plants, animals, fungi and microorganisms for food, clothing, medicine, various services, shelter and industrial materials. In spite of an understanding of this reciprocal linkage between development and environment, however, only a small fraction [2-5%] of biological diversity has been surveyed, authenticated and widely used over the past 300 years. For example, out of an estimated total of 5-80 million species on planet Earth, only 1.4 million have been authenticated and given scientific names [Wilson 1988]. Similarly, habitats and ecosystems in the boreal and terrestrial zones have been studied intensively in comparison to tropical and marine environments.

Vast areas of biological diversity are largely unknown, therefore, particularly in the tropics and the marine environment, and among insects, other invertebrates and microorganisms. Yet, 50% of species diversity occurs in closed tropical forests which are being destroyed at the rate of 5-10% every 10 years, causing the extinction of about 100 species per day. The current loss of biological diversity includes that which is known and unknown [or still undiscovered]. The causes of this loss are both direct and indirect:

[1] **Habitat and ecosystem destruction** in the process of spatial conversion for economic uses [e.g. large-scale monoculture plantations], resulting in the extinction of genetic and species diversity;

[2] **Habitat and ecosystem fragmentation** in the process of spatial transformation for economic uses [e.g. industrial complexes, small-holdings], resulting in the reduction of genetic and species variability;

[3] **Species overexploitation** for trade and economic use [e.g. ivory trade, trawl-fishing], resulting in loss of species and genetic variability and destruction of habitat and ecosystem diversity;

[4] **Disease epidemics and predation pressures** in simplified and attenuated ecosystems that were previously not known, resulting in reduction of species, genetic and habitat and ecosystem variability;

[5] **Species displacement** by the invasion of exotic species or virile mutants, resulting in loss of species and genetic diversity and variability, and in reduction of habitat and ecosystem diversity; and

[6] **Pollution** [e.g. acid rain, eutrophication] of habitats and ecosystems, resulting in loss of species and genetic diversity, and reduction of habitat and ecosystem variability.

Although there is no possibility of surveying and authenticating all the biological diversity on planet Earth in view of the rate of destruction of tropical forests [1-5% per decade], isolated habitats and of the marine environment, it may be possible to conserve 10-20% and significant proportions of it within the next 10-20 years by allocating additional resources to strategic elements of a coordinated programme. This has been recognised by the Ad-Hoc Working Group of Experts on Biological Diversity of the United Nations Environment Programme [UNEP 1988a, b & c].

1.4 Materials and Methods

Materials for this case study on the global needs and costs of conserving biological diversity were obtained from bilateral and multilateral organizations, non-governmental international organizations, governmental organizations and individual experts mainly in Europe and North America. It involved brief field visits to Washington, New York, Paris, Geneva and Rome to meet with institutions and experts, discuss with them the issues that were raised and to obtain from them appropriate [even draft] documentation wherever possible. In spite of time constraints, the following organizations and their staff provided useful information generously:

* The Chilean National Union for the Environment [PNUMA],
* The Commission of the European Communities [ECE],
* The Commonwealth Science Council [CSC],
* The Conservation International Foundation [CI],
* The Consultative Group on Biological Diversity [CGBD], at the Rockefeller Brothers Fund,
* The Consultative Group on International Agricultural Research [CGIAR],
* The Convention on the International Trade on Endangered Species [CITES] Bureau,

* The Convention on Migratory Species [CMS] Bureau,
* The Council of Europe [CE],
* The Dag Hammarskjold Foundation,
* The Danish National Forest and Nature Agency,
* The Ethnobiological Institute for Amazonia [INEA],
* The Finnish Ministry of the Environment,
* The Food and Agriculture Organization of the United Nations [FAO],
* The Inter-American Development Bank [IADB],
* The International Association for Ecology [INTECOL],
* The International Board on Plant Genetic Resources [IBPGR],
* The International Council of Scientific Unions [ICSU],
* The International Fund for Agricultural Development [IFAD],
* The International Institute for Tropical Agriculture [IITA],
* The International Union of Biological Sciences [IUBS],
* The International Union for the Protection of New Varieties of Plants [UPOV].
* The National Academy of Sciences of the United States [NAS],
* The Natural Resources Defence Council [NRDC],
* The Oxford Forestry Institute [OFI],
* The Ramsar Convention Bureau,
* The Royal Botanic Gardens Kew,
* The Royal Society of London,
* The Smithsonian Institution or the United States Museum of Natural History,
* The United Nations Centre for Science and Technology for Development [UNCSTD],
* The United Nations Development Programme [UNDP],
* The United Nations Educational Scientific and Cultural Organization [UNESCO],
* The United Nations Environment Programme [UNEP],
* The United States Agency for International Development [USAID],
* The U.S.S.R. Nature Conservation and Environmental Protection Institute,
* The World Bank or the International Bank for Reconstruction and Development [IBRD],
* The World Conservation Monitoring Centre [WCMC],
* The World Conservation Union or the International Union for Conservation of Nature and Natural Resources [IUCN],
* The World Heritage Convention Bureau,
* The World Resources Institute [WRI],
* The World Wide Fund for Nature Conservation [WWF - UK],
* The World Wide Fund for Nature Conservation [WWF - International], and
* The World Wildlife Fund [US].

Individuals in these and other organizations who were helpful in providing information are acknowledged in Annex.

1.5 Constraints

The material received and information obtained for this case study was too patchy to address the terms of reference in full,

especially the detailed costs of a global strategy and programme for conserving biological diversity over the next 10-20 years. It is doubtful if such a cost estimate can be realised meaningfully without fully consulting countries in the tropics and their trading partners, all maritime countries and a variety of experts knowledgeable about biological diversity, resource transformations and technological innovations, in view of the paradox underlying international trade and development. Development investments affect biological diversity by transforming natural resources [or the "outer" limits of the biosphere], and concurrently prescribe the limits for realising the aspirations of all people affected and involved for a more equitable and a better quality of life [or the "inner" limits of human advancement]. Although the tropical and marine environments possess much of the global heritage of biological diversity which is currently threatened by population and economic growth pressures, the countries in these environments are essentially developing and are acutely short of financial resources, training facilities and technical expertise for managing this natural global heritage even for their own welfare and advancement. These countries are thus constrained in making effective use of any new international approach or fund for development, that may became available for the conservation of biological diversity on a global scale.

2 NEEDS AND COSTS OF A GLOBAL STRATEGY

The Ad-Hoc Working Group of Experts on Biological Diversity of the United Nations Environment Programme decided that existing conservation conventions and other relevant international programmes were essentially sectoral and could not adequately meet the aim of conserving biological diversity at the global level [UNEP 1988a, b & c]. It further decided on areas of basic global needs [see above] that should contribute towards the framework of a global strategy for conserving biological diversity, which would build on current conventions and programmes [UNEP 1990]. An overall assessment of the cost of a global strategy for conserving biological diversity over the next 10-20 years must assume consultation with experts, countries and regions, and with ongoing programmes of global significance. However, in the limited time available for this case study, it was not possible to conduct these full consultations. A variety of inter-governmental and non-governmental programmes, together with the framework of a global strategy [see Section 3 below], were used to arrive at a magnitude of the cost estimates for such a global strategy for conserving biological diversity.

Implementation of a global strategy for conserving biological diversity, and promoting the sustainable use of natural resources in the future, demands:

* An understanding of the pace and unpredictable pattern of technological innovations in transforming natural resources into useful products and commodities, and thereby impacting the environment, in response to changing human perceptions of sustainable economic livelihoods and needs concurrently at local and global levels;

* Reliable information for resource development and environmental management;

* Integrative strategies for conserving biological diversity with cultural development; and

* Regional and global coordination of plans and programmes which promote local adaptation and implementation.

There is very little new information being generated currently about the nature of biological diversity in the tropics and the marine environment where much of it resides and is of global significance, and about its management. Most of this information originates from research investments by the non-governmental sector; and 90% of research [and presumably management] efforts on biological diversity are concentrated in the polar and not the tropical zones. This skewed distribution of information for the conservation of biological diversity is exacerbated by two further factors: [1] computerised collations on conservation issues which often appear to provide "global" figures about biological diversity without exhibiting an in-depth appreciation of the complexities of the issues concerned; and [2] the trend in many cases to aggregate the traditional sectors of forestry, agriculture and fisheries under "biological diversity".

It is difficult to estimate the magnitude of additional funds required for a global strategy for conserving biological diversity due to the paucity of information available, and shortcomings in its clarity and reliability. Even though nation states and development assistance agencies already spend billions US$ annually for nature protection and environmental management, a global conservation strategy will require additional funds in view of the gaps in current conservation programmes. There is a shortfall of funds in most developing countries in the tropics for conserving biological diversity. For example, the three countries of East African, Kenya, Tanzania and Uganda, have a budget of US$11 million per annum for administering wildlife protection when their needs amount to US$84 million per annum; and an administrative budget of US$1.1 million per year in Tanzania generates revenue earnings of US$4.5 million per annum. The official development assistance on a worldwide basis exceeds US$40 billion per annum and very little of it concerns the conservation of biological diversity. The World Resources Institute has estimated the need for additional funds amounting to US$20-50

billion per year for a global strategy for conserving biological diversity [WRI 1989]; the World Wide Fund for Nature Conservation [UK] has estimated the need for an additional US$100 million per year; and the Union of the Soviet Socialist Republics has estimated its additional needs in terms of US$1.00 billion per year. Professor David Pearce [pers. comm.] has estimated the need for a transfer of US$3.2 billion per annum to conserve tropical forests based on the existence value of tropical species and habitats in the rich industrialised countries. While there is considerable variation in the figures and uncertainty about their basis, additional funds **at least of the order of hundreds of millions to units of billions US$ per year** appear necessary for surveys and inventories, identification and authentication, technical assistance and cooperation in research, curation, education and training and traditional uses, management strategies and plans, monitoring and conservation coordination, priority projects and for the transfer of technology, for conserving 10-20% of biological diversity especially in tropical and marine environments over the next 10-20 years. The availability of any additional funds will have to be phased gradually to match their absorptive capacity especially in developing countries in the tropics.

3 ELEMENTS OF A GLOBAL STRATEGY

On the basis of global conservation needs identified by the Ad-Hoc Working Group of Experts on Biological Diversity of the United Nations Programme, the following specific elements should be identified in a global strategy for conserving biological diversity over the next 10-20 years:

[A] Formation of a consensus on international priorities for maintaining biodiversity;

[B] Provision of a framework for detailed regional action plans to stem the loss of biodiversity;

[C] Realization of opportunities to use the Regional Action Plans to benefit local and indigenous populations;

[D] Development of an Emergency Action Plan for Protected Areas for regions that require special attention, and for new protected areas needed in regions that scientists agree have the greatest biodiversity value;

[E] Research into the identification, clarification, promotion and sustainable use of tropical biological resources outside the main band of species now exploited;

[F] Research into the ways in which indigenous people harvest useful substances from tropical wild lands on a sustainable basis; and

[G] Cost of obtaining patent protection for new medicines and other chemicals derived from tropical species in order to overcome the private sector's reluctance to spend money on research in this area.

Each of these elements of a potential global strategy are discussed separately.

3.1 Consensus on International Priorities

Formation of a consensus on international priorities for maintaining biological diversity relies on the availability of reliable information on genetic, species and habitat and ecosystems diversity nationally as well as regionally. It will require regional and international meetings and consultations to coordinate conservation action; and will depend on a national and regional capability for monitoring the status of conservation of biological diversity. International conservation priorities should include issues pertaining to large areas with high biological diversity [e.g. tropical forests, coral reefs] or with low biological diversity [e.g. tundra, deserts, open sea], besides small areas with high endemism [e.g. oceanic islands, isolated mountains and lakes], especially in the tropics and the marine environments. There will be the need to assess regional and international priorities for conserving taxa, areas, depositories, repositories, technology transfer and technical expertise. Consensus formation should be based on one or more of the following mechanisms: specialist consultations, broader technical consultations, governmental consultations, public awareness campaigns and consultations, and international advisory meetings. Although the costs of consensus formation are difficult to assess, they should require additional funds of about US$10 million per year in view of the cost of coordinating the International Biological Programme [IBP] at US$1-3 million per year and the costs of programme coordination of the World Conservation Union [IUCN] at US2-3 million per year.

3.2 Regional Action Plans

3.2.1 Introduction

There is a need to provide a framework for regional action plans to stem the loss of biological diversity especially in the tropics and the marine environment, by coordinating conservation strategies and plans with sustainable development policies. Regional action plans should relate to the international priorities for conserving biological diversity; and should generate new information on conservation and development by promoting surveys and inventories, the function of depositories and repositories, identification and authentication, the study of key ecological processes, the integrated management of technology transfer, and

by promoting the training of appropriate professional expertise. These plans can only be developed in consultation with countries in a region, and by examining the gaps in regional action plans already in existence. The information collected was inadequate to permit assessment of such gaps.

3.2.2 Existing Regional Action Plans

A variety of regional action plans already exist under the sponsorship of international intergovernmental and non-governmental organizations; and promote the conservation of one or more aspects of biological diversity. These are complemented by regional actions of bilateral development assistance agencies. It has not been possible to survey the range of regional plans in operation. The following selection is an illustrative list:

* **The World Commission on Plant Genetic Resources** under the auspices of the FAO.UN has a defined programme on the conservation of plant species of food, agriculture and forestry potential. It is executed through a network of national institutions with regional collaboration in the collection, storage or planting and testing of material. The programme is reviewed every five years by expert panels.

* **The International Board on Plant Genetic Resources** has a coordinated programme at its regional international centres for agricultural research, to collect, store and test plant material of the main food crops. Each centre is dedicated to a specific crop or to crops of a region; and field tests include farming systems trials in a region.

* **The Tropical Forestry Action Plan** is a global framework for action in tropical forestry. It's coordinating unit is located at the Food and Agriculture Organization of UN. It involves >5-10% of the overseas development assistance [ODA], and in 1986 consumed US$515 million for investment and $393 million for technical assistance [Table 1] [FAO 1987]. Bilateral and multilateral development assistance agencies contribute equally to this Plan. Conservation of tropical forest ecosystems is one of the five priority areas of this plan, and it involves approaches for:

  * Sustainable use of the forest for the production of wood, food, fodder and other non-wood products;

  * A series of protected areas;

  * Maintenance of intraspecific variation of species of actual or potential socioeconomic importance and other species;

  * National parks and protected areas within the pattern of land use of benefit to local people;

* Closer linkages between biological diversity conservation policies and recovery of natural vegetation for watershed protection;

* Assembly of information on germplasm collection;

* Public awareness about biological diversity conservation; and

* Staff training.

Only a small proportion of TFAP funds has been used for ecosystems conservation [5%] and watershed management [30%], with most allocated to Africa [42%] and the Asia-Pacific [41%] regions [FAO 1987]. However, the TFAP has generated multiplier effects mainly in the form of bilateral cooperative [332/593 cooperative actions]. The plan aimed to raise US$8 billion over five years, but does not appear to have reached its target.

* **The Man and Biosphere [MAB] Programme** of the United Nations Educational Scientific and Cultural Organization promotes research, training and development on various aspects of biological diversity conservation. It has a representative coverage of ecosystems on a global scale known as Biosphere Reserves. Its programmes are coordinated regionally, but its assured funds are only about US$1.1 per annum.

* **UNESCO's Mangrove Programme** also promotes research, training and development on various aspects of biodiversity conservation. It also is coordinated regionally.

* **The Intergovernmental Oceanographic Commission's** regional programmes, like that for the Western Pacific, promotes research, training and development of marine resources conservation near-shore and off-shore. It is regionally coordinated.

* **The Regional Seas Programme** of the United Nations Environment Programme promotes research, training and development of marine conservation and environmental protection. It is coordinated regionally.

* **National Conservation Strategies** under the auspices of the International Union for Conservation of Nature and Natural Resources have been restricted hitherto. There are moves to promote them on a regional basis in the near future.

3.2 3 Effective Coordination

Coordination of the various regional action plans concerning the conservation of biological diversity is carried out to some extent by the Ecosystems Conservation Group [ECG]. This Group is currently limited in membership, and consists of the Food and

Agriculture Organization of the UN [FAO], the United Nations Educational Scientific and Cultural Organization [UNESCO], the United Nations Environment Programme [UNEP] and the World Conservation Union [IUCN]. **The effectiveness of these regional action plans and other emerging programmes should be assessed in terms of:**

[1] Promoting research, training and development of technologies for conserving biological diversity in-situ and ex-situ;

[2] Focusing on plants, microorganisms and terrestrial and aquatic invertebrates for species conservation, and on tropical and marine environments for habitat and ecosystem conservation;

[3] Catalysing national programmes for biological diversity conservation;

[4] Promoting sustainable use of resources, and the development of appropriate tools for integrated assessment;

[5] Training local expertise in a variety of conservation technologies; and

[6] Establishing and maintaining networks of cooperating individuals and institutions on different facets of biodiversity conservation.

Networks of individuals and institutions cooperating regionally or internationally are an inexpensive and efficient mechanism for promoting regional action and calibration on the conservation of biological diversity. Their success however depends on:

* A clear definition of the problem for conserving biological diversity that is common to the region;

* Identification of a "lead" centre capable of providing leadership on the problem defined, with the prospect of rotating this role among participants;

* Identification of network participants for their expertise and strong commitment to make a contribution;

* Encouraging active participation and providing resources or support as may be necessary; and

* Promoting communication and feed-back, including the exchange of material and results.

Regional action plans should be able to promote surveys and inventories, identification and authentication services; technical assistance and cooperation for biological diversity research, depositories and repositories, socio-economic research, education and training, management strategies and plans, and monitoring; and priority projects to demonstrate conservation and sustainable use technologies, and in different biome types.

3.2.4 Surveys and Inventories

Surveys and inventories of genetic, species and habitat and ecosystems diversity have been patchy and inadequate due largely to the strategic and limited investments of metropolitan or industrialised countries, and to the scarcity of resources and technical expertise in developing countries especially in the tropics. Nevertheless, commercial institutions have been involved in surveys and inventories having a direct market interest, governmental and inter-governmental institutions in those of importance to national security especially in natural resources and land and water use, and universities and private institutions have been involved in those usually not perceived important for strategic development. There has been a hiatus of 50-80 years in international surveys and inventories since the early part of this century due to the emergence of independent nation states and transitions towards global governance. However, such surveys have been stimulated recently through international scientific programmes such as the International Biological Programme [IBP], the Man and Biosphere [MAB] Programme and the International Geosphere-Biosphere Programme [IGBP], and through the commercial search for alternative phyto-chemicals for industries.

Biological diversity of immediate importance to natural resources development [i.e. agriculture, fisheries and forestry] has been better surveyed than others. Similarly, unique species, habitats and ecosystems of touristic and recreational importance have been better surveyed than others. As a consequence, for example, only 2.5 million species or taxa have been surveyed especially over the past 300 years, out of an expected potential of 25 million species, although some estimates suggest 30-80 million species due to the predominance of insects in tropical forests and invertebrates in the seas [Wilson 1988]. The patchiness of these surveys can be illustrated by poor knowledge about microorganisms of which about 13% are known, but which perform important roles "bridging" the interfaces of the geosphere, biosphere and atmosphere [Hawksworth in di Castri and Younes 1990]; and by poor knowledge about insects and invertebrates, <10% of which are known.

Surveys and inventories of biological diversity have an essential geographic component. They are complete only when collecting or survey in a particular area ceases to yield any new information on varieties or forms. However, they are still yielding new varieties of genes, taxa and habitats and ecosystems particularly in tropical and marine environments which have been surveyed inadequately hitherto. In the Brazilian Amazon, for example, the rate of discovery of new taxa or species is 1-9% of determinations for plants [Campbell 1989]. It is likely to be much higher for invertebrates particularly insects which dominate tropical ecosystems, and for microorganisms and marine benthic species which have been poorly studied; and for other biogeographic regions which have been less well surveyed.

Table 1: Collection Density [D] [1981] of Herbarium Specimens and Rates of Botanical Inventory [N] in Tropical Countries/Regions

REGION/COUNTRY	D	N	REGION/COUNTRY	D	N
ASIA & AUSTRALIA			**AFRICA**		
China	50	21	Sierra Leone	50	43
Taiwan	534	0	Liberia	6	*
Philippines	42	5	Ivory Coast	7	*
Thailand	23	*	Ghana	48	58
Malaysia & Singapore	219	0	Benin & Togo	5	126
Brunei	123	0	Nigeria	14	175
Indonesia	86	18	Cameroun	10	65
Papua New Guinea	46	193	Gabon	1	618
Burma	5	676	Congo	9	*
India	107	0	Zaire	5	*
Sri Lanka	152	0	Central African R.	1	*
Australia	56	117	Angola	5	90
Pacific Islands	529	0	Uganda	7	*
SOUTH AMERICA			Kenya	64	27
The Guianas	11	741	Tanzania	5	398
Venezuela	23	59	Madagascar	9	*
Colombia	30	39	**CENTRAL AMERICA**		
Ecuador	21	70	Mexico	48	13
Peru	28	77	Belize	17	133
Bolivia	1	707	Guatemala	34	42
Brazil	25	59	El Salvador	268	0
CARIBBEAN			Honduras	136	0
West Indies Islands	261	0	Nicaragua	22	34
			Costa Rica	236	0
			Panama	44	12

N = No. of years required to reach a satisfactory collection density [D]; * = Infinity

SOURCE: Campbell [1989]

Various indices have been developed to gain an understanding of the adequacy of surveys and inventories. For example, a collection "density index" [No. of specimens deposited per 100 sq km] has been used as a measure of adequate sampling of an area; and an index of 100 has been designated arbitrarily to indicate that an area has been sufficiently sampled for plants in terms of specimens deposited in local herbaria [Table 1] [Campbell 1989]. Although this may be a low index for regions where many early and valuable specimens have been deposited in European and American collections in the course of the colonial history of many tropical countries, it is nevertheless useful in demonstrating that tropical Asia, Oceania, Central America and the Caribbean have been better surveyed for plants than tropical Australia, South

America and Africa. On the basis of such information, priority areas can be identified for future botanical explorations [Table 2] [Campbell 1989]. A similar situation probably prevails for the higher vertebrates and butterflies which have attracted the interests of naturalists. In contrast, microorganisms, lower plants, terrestrial and aquatic invertebrates particularly insects and the lower vertebrates have been less well surveyed. In view of differences in taxonomic specialisation, there is no concurrence among scientific experts on the priority areas for future survey of biological diversity.

Table 2: Areas of Highest Priority for Botanical Surveys

REGION/COUNTRIES	REGIONS/COUNTRIES
ASIA	**AFRICA**
India: Nagaland	Sierra Leone: interior
Thailand: central plain, NW & W highlands	Liberia: interior
Vietnam: NE and Danang-Hue	Ivory Coast:
Laos: southern	Ghana: SW
Kampuchea: SW	Nigeria: delta, E
Philippines: Luzon mountains, Samar-Leyte limestones, Mindanao mountains, Mindoro and Palawan	Cameroun:
	Zaire:
	Kenya: rift valley, E and mountains
Borneo: mountains, islands, NW	Tanzania: rift valley and mountains & plateaus
Sumatra: N and N islands, E, SE and S islands	Uganda: mountains
	Madagascar:
Sulawesi: N, central and SW	**CENTRAL AMERICA**
Moluccas:	Mexico: highlands, E coast
New Guinea: mountains, lowlands and adjacent islands	Guatemala: highlands, S Peten
	Honduras: highlands, coasts
SOUTH AMERICA	Nicaragua: highlands, coasts
Venezuela: highlands	Costa Rica: highlands
Colombia: highlands, coasts	Panama: highlands, coasts
Ecuador: highlands, coasts	**CARIBBEAN**
Peru: highlands, Amazon	Dominican Rep.: highlands
Bolivia: Amazon	
Brazil: Amazon, E coast	

SOURCE: Campbell [1989]

Genetic diversity has been poorly surveyed except for species of immediate economic importance. For example, out of 80,000 plant species which provide suitable food for humans, only 150 species have ever been cultivated on a large scale, and less than 20 species provide 90% of the world's food. It would be extremely difficult and expensive to survey genetic diversity in a comprehensive manner, and a selective approach must therefore be used.

Habitats and ecosystems have also been inadequately surveyed in the tropics and oceans in comparison to the temperate and boreal zones because of differential research capabilities and investments. Udvardy's [1975] classification provides a generalised picture of tropical biomes and ecosystem types. It is not applicable to the marine environment; and therefore needs to be reexamined and refined by the application of modern advances in community ecology to the understanding of biotopes and ecosystem types in the tropics and by the role of ocean currents in dispersing larval forms in the marine environment.

In view of the foregoing, **a state-of-the-art review of biological diversity is therefore urgently needed especially for the tropics and the marine environment, and for microorganisms, invertebrates and lower vertebrates**. It will enable planning of future surveys, identification of their location or concentration and monitoring of concerted international action.

The technology used for surveys and inventories of biological diversity have not changed significantly in being [a] labour-intensive and [b] dependent on specialised technical expertise. Technological advances of importance have occurred in areas of commercial interest such as genetic "fingerprinting" for assessing genetic diversity, electron and interference microscopy for species diversity, and remote-sensing for assessing habitat and ecosystems diversity related to functional criteria. There is a need for promoting the wider application of these advances to surveys and inventories of biological diversity.

It is difficult to cost future surveys and inventories of biological diversity at this stage. Many of the costs are hidden in the voluntary and dedicated efforts of a small proportion of individuals. However, on the basis of taxonomic uncertainty, at least a 6-10 fold increase in resources is needed to obtain a reasonable understanding of biological diversity in the tropics and the marine environment, in comparison to the resources expended over the past 250 years, particularly in view of its rapid extinction and destruction. For flowering plants, for example, additional funds amounting to US$33-66 million would be required to discover 10-20% more species respectively, based on a conservative unit cost of US$2,630 for the discovery of a new taxon in the tropics. If plants are only 10% of all the species determined thus far, then additional funds amounting to US$330-660 million would be needed to discover 10-20% more new taxa. This is a

conservative estimate in comparison to the 6-10 fold more taxa estimated to occur on this planet, which could cost US$1-5 billion to survey and inventory. On the basis of an escalation in the magnitude of technology used, the costs for habitat and ecosystem surveys at one order of magnitude greater than species surveys could be US$10-50 billion; and the costs for genetic surveys at two orders of magnitude greater than species surveys could be US$100-500 billion. However, it is unrealistic to consider comprehensive surveys at this stage due to the rate of loss of biological diversity and to the limited absorptive capacity of additional large investments in tropical developing countries where this diversity is located, and where only 10% of the professional expertise of the industrialised countries can be found. It would be realistic to plan for an additional expenditure of 10-20% of the total estimated costs of surveys and inventories over the next 10-20 years in view of the rapid degradation of terrestrial and marine habitats in the tropics; and this could mean **an additional US$330-660 million for all taxa, US$1-5 billion for habitat and ecosystems surveys, and US10-50 billion for genetic surveys**. However, even this is somewhat unrealistic since surveys and inventories are usually undertaken in conjunction with other functions like authentication. **Assessment by local communities, provinces and countries of their priority needs for new knowledge is essential for successful surveys and inventories, and this has to be undertaken in relation to spatial areas, habitat and ecosystem types, taxonomic and species ranges, genetic variability, survey and use technologies, and technicians and expertise**. For example, the framework used by the United States of America when undertaking its survey on plant diversity needs in the early 1980s [Table 4] could be adapted for other target groups of species such as microorganisms, terrestrial and aquatic invertebrates and marine biota, and for tropical and marine habitats and ecosystems, all of which are poorly known.

3.2.5 Identification and Authentication

Not all the biological diversity surveyed has been identified and authenticated. If one examines the authentication of species diversity, for example, only 1.435 million taxa have been identified and authenticated in comparison to the 2.5 million surveyed and the estimated total of about 25 million taxa [Wilson 1988; McNeely, Miller, Reid, Mittermeier and Werner 1990]. Much of this is due to inadequate investments in taxonomy, the shortage of expertise in the tropics especially on microbia, invertebrates and marine biota, and to the remote location of the major reference collections in the temperate zone countries. On the basis of an estimated total population of 1,500 taxonomists in 1980, there appears a need for about 7,500 more taxonomists [McNeely et al. 1990]. Training such expertise is time-consuming requiring 3-5 years to gain proficiency after a basic degree, is expensive requiring at least US$15,000 per person per year, and is demanding on supervision and apprenticeship. Inadequacies in basic taxonomic training at this level in authentication and

verification can seriously jeopardise other forms of research and resource transformations. Given the disproportionate prevalence of scientific expertise in the industrialised temperate zone countries, it is unlikely that developing countries in the tropics could provide all the expertise required for authenticating their biological diversity heritage. Information was not available to assess the needs for authenticating genetic and habitat and ecosystem diversity; although it would be more expensive to train expertise in these areas by about two-fold in comparison to species diversity due to expensive laboratory or field equipment required. Institutions with expertise for training in these areas are relatively scarce in tropical developing countries.

Holdridge [1967] has developed a life-zone system for classifying terrestrial habitats and ecosystems. This needs to be refined further with respect to species associations. A similar system is lacking for the marine environment especially for the open sea.

Table 3: Knowledge of Floras in 82 Tropical Countries

STATE OF KNOWLEDGE: / REALMS:	NATIONAL CHECK-LIST OF PLANTS	FLORA IN PREPARATION	FLORA PREPARATION VERY ADVANCED	IUCN LIST OF THREATENED SPECIES AVAILABLE	OTHER LISTS OF SPECIES AVAILABLE
AFROTROPICAL	7	19	16	7	1
NEOTROPICAL	-	10	1	1	3
INDOMALAYAN	1	11	-	1	-
AUSTRALIAN	-	1	-	1	1
OCEANIAN	-	-	-	-	-
TOTAL [82]	8	41	17	10	5

SOURCE: Lucas and Synge [1978].

As a consequence, the knowledge about classification of biological diversity is very patchy. For example, tropical floras appear better known for Africa [Table 3] [Lucas and Synge 1978] even though they may have been inadequately surveyed [Table 1]; and it would take at least two decades to complete the floras under preparation. Countries could use the approach used by the United States of America when assessing its own knowledge and needs about plant diversity [Table 4], to determine their own needs for surveys, depositories and repositories, identification and authentication, understanding ecological processes, promoting R&D and technological innovation, and undertaking training and consultations. Each of these steps is expensive. For example, the maintenance of a living plant species ex-situ in a depository costs about US$500 per year; and such expenditures are difficult to access in budget allocations when financial resources are in scarce in developing countries. As a consequence, **assessment of**

needs for identifying and authenticating biological diversity in tropical and marine environments must relate especially to taxa and classification systems of importance to the local and international economy, to management and technological innovation, and of importance to the strategic training of specialists.

Table 4: Knowledge about Plant Species Diversity

CATEGORY:	I	II			III			IV			
PLANT GRP	1	2	3	4	5	6	7	8	9	10	11
IDENTIFICATION	H		H			H				NA	
ACQUISITION	NA		NA			M				H	
MAINTENANCE	Lx Hi		Lx Hi			Hx Hi				Hx Li	
EVALUATION	H		H			H				H	
ENHANCEMENT	NA		NA			L-M				H	
MONITOR GENETIC VULNERABILITY	NA		M			H				H	
INFORMATION MANAGEMENT & COMMUNICATION	H		H			H				H	
TRAINING	H		H			H				H	

PLANT GROUPS: 1 = Unclassified species, 2 = Named species, 3 = Distribution known, 4 = Synecology known, 5 = Usefulness primitive, 6 = Composition known, 7 = Exploited from the wild, 8 = Progenitors of cultivated species, 9 = Minor local crops, 10 = Minor extensive crops, 11 = Major crops

x = ex-situ, and i = in-situ

CATEGORIES: I = Species with essentially no information,
II = Species of known taxonomy, and general distribution and ecology,
III = Species not cultivated but with some useful potential,
IV = Cultivated species and their progenitors with local, regional or global economic importance.

SOURCE: DOS [1982].

3.2.6 Ecological Research

The ecological processes sustaining biological diversity are complex [Table 5] and have been poorly examined in tropical marine and terrestrial environments. This paucity of knowledge is due to taxonomic uncertainties, complex interactions at the photic [or canopy] and substrate [or benthic] zones, horizontal and vertical ecotonal linkages [e.g. land-water], a high degree of symbiosis, the dominance of biotic factors [e.g. predation and parasitism] in natural selection in contrast to abiotic factors in the polar and arid regions, difficulties in characterising patch dynamics, and to shortages in funding and of professional expertise. Most such studies have been undertaken by private and academic institutions; although some autecological studies have been pursued through inter-governmental organizations such as the World Commission on Plant Genetic Resources and the Tropical Forest Action Plan.

Understanding the ecological processes maintaining biological diversity is important for several reasons. For example, many chemical products produced by plants are generated in response to interactions with specific animals. Land-water ecotones, for example, are often characterised by higher species diversity than adjacent patches due to an optimal interaction between patch [or mosaic] size and edge effects [Naiman, Decamps and Fournier 1989]. This kind of knowledge has been used traditionally by farmers in the dyke-pond systems of southern China and in the home gardens of Mexico and Indonesia, for example, to saturate their planting systems with habitats and species to reduce the risk of any single crop failure, to recycle waste materials from one sub-system into another and to optimise biomass production per unit area of land and water. Transition zones are important, therefore; and an understanding of ecotone-biodiversity relationships is necessary for managing landscape mosaics. Species with an alternation of generations [e.g. insects, parasites] and mobile or migratory species [e.g. birds, fishes] complicate such relationships by using more than one ecotone or ecosystem in their life-cycle. There is a need to **assess the ecological processes important at the local, provincial and national levels for sustaining biological diversity in the tropical and marine environments in terms of key factors operational at each level and between levels, the role and nature of perturbations, the causes of high species diversity and endemism, and the causes of threat and extinction**.

It is difficult to estimate the cost of ecological research related to biodiversity since it would be determined by the nature and complexity of the problem. However, on the basis of the availability of US$0.5 million per annum to stimulate and coordinate research in each country, an initial sum of US$50 million could be needed per annum.

Table 5: Ecological Processes Sustaining Biological Diversity

[A] GENETIC DIVERSITY

1 Mutation: Random or Directed
2 Genetic Drift: Clinal variation, Isolation
3 Reproductive Systems: Sexual or Asexual [Fission, Parthenogenic, Vegetative]
4 Pollination or Fertilisation Systems: Mass Transfer [Wind, Thrips, Water Currents] or Selective [Bats and Bees, Moths and Butterflies, Internal or External]
5 Mating Systems: Random or Assortative [Phenotypic positive or negative, Genotypic positive]
6 Selection Pressure: Abiotic or Biotic [Predation, Parasitism]

[B] SPECIES DIVERSITY

1 Environmental Tolerance: Morbidity and Lethal Limits, Antagonistic and Synergistic Effects, "Edge" Effects
2 Niche: Size, Specialist or Generalist
3 Alternation of Generations [Phases]:
1-Phase [Egg/Seed-Adult]: microbes, plants, most animals
2-Phase [Egg-Larva/Vegative-Adult/Reproductive]: insects, coelenterates, bryophytes, cestodes, molluscs, protozoans
3-Phase [Egg-Larva 1-Larva 2-Adult]: trematodes
4 Reproductive Strategies: Many young widely-dispersed [r] or few young narrowly-dispersed [k]
5 Population Dynamics: Life-table, Size, Competition, Solitary or Aggregations, Social Organizations
6 Habitat and Isolate: Size, Degree of Isolation, Vertical Stratification, Horizontal Discontinuity, "Edge" Effects, Land-Water Ecotones, Lowland-Highland Ecotones
7 Trophic Dynamics: Herbivory, Detritivory, Predation [Predator-Prey], Parasitism [Host-Parasite]
8 Interspecific Interactions: Symbiosis, Protocooperation, Mutualism, Commensalism

[C] ECOSYSTEM OR COMMUNITY DIVERSITY

1 Energy Flow: Photosynthesis, Chemosynthesis, Grazing Pathways, Detritivore Pathways
2 Material Cycles: Nutrients, Water, Biomass, Production, Decomposition
3 Spatial Scales: Biotopes or Mosaics, Landscapes, Regions [Meso-scale], Global [Macro-scale], "Edge" Effects [Horizontal, Vertical]
4 Temporal Scales: Days, Weeks, Months, Years, Decades, "Generations", Centuries, Millennia
5 Information Diversity: Genetic, Species, Community, Landscape, Cultural

SOURCE: J.I.Furtado, based on NRC [1989]

3.2.7 Areas of Endemism and Radiation

International priorities and regional action plans for conserving biological diversity must consider areas of endemism and high species and habitat diversity under threat from resource transformation pressures. There are 12 countries mainly in the tropics which are very rich in species diversity ["megadiversity"] and account for 60-70 % of global diversity [Wilson 1988]:

* **Brazil**
* **Colombia**
* **Ecuador**
* **Peru**
* **Mexico**
* **Zaire**
* **Madagascar**
* **Australia**
* **China**
* **India**
* **Indonesia**
* **Malaysia**.

These correspond somewhat to the regions of high endemism ["hotspots"] in tropical forests [Myers 1988]:

* **Atlantic Brazil**
* **W Amazonian uplands**
* **W Ecuador**
* **Colombian Choco**
* **Madagascar**
* **Eastern Himalayas**
* **Peninsular Malaysia**
* **Northern Borneo**
* **Philippines**
* **New Caledonia**
* **NE Australia**.

These areas have been among the centres of origin of cultivated plants ["Vavilov Centres"]:

* **S Chile**: Potato
* **S Brazil and Paraguay**: Cassava, Peanut, Cacao, Rubber, Pineapple
* **Peru, Ecuador and Bolivia**: Sweet Potato, Potato, Lima bean, Tomato, Papaya, Tobacco, Sea Island Cotton
* **S Mexico and Guatemala**: Corn, Common bean, Pepper, Upland Cotton, Sisal Hemp, Squash, Pumpkin, Gourd
* **Ethiopia**: Wheat, Barley, Chickpea, Lentil, Pea, Teff, African Millet, Flax, Sesame, Castor bean, Coffee
* **Mediterranean**: Wheat, Hulled Oats, Broad bean, Cabbage, Olive, Lettuce
* **Near East [Asia Minor]**: Wheat, Barley, Rye, Red Oat, Chick pea, Pea, Lentil, Blue Alfalfa, Sesame, Flax, Melon, Almond, Fig, Pomegranate, Grape, Apricot, Pistachio
* **Afghanistan, Pakistan and NW India [Central Asia]**: Wheat, Rye, Pea, Lentil, Chickpea, Sesame, Flax, Safflower, Carrot, Radish, Pear, Apple, Walnut
* **Indo-Burma**: Rice, African Millet, Chickpea, Mothbean, Rice bean, Horse gram, Asparagus bean, Eggplant, Taro Yam, Cucumber, Tree Cotton, Pepper, Jute, Indigo
* **Thailand, Malaysia and Indonesia [Indo-Malaya]**: Yam, Pomelo, Banana, Coconut
* **C & E China and Korea**: Naked Oat, Soybean, Adzuki bean, Common bean, Leaf Mustard, Apricot, Peach, Orange, Sesame, Chinese Tea

In the marine environment, the Indo-Pacific archipelago, the western Indian Ocean and the Caribbean sea have high species diversity. Isolated oceanic islands [e.g. Hawaii], lakes [e.g. Baikal] and mountains [e.g. New Guinea] also have high endemism. Large areas [e.g. tundra, deserts, open sea] have low species diversity but are important for supporting migratory species. International conservation priorities and regional action plans should include **consideration of large areas with high and low diversity, and small areas with high endemism**.

3.2.8 Depositories and Repositories

Depositories of biological diversity and repositories of information on biological diversity occur in various forms. Many of these are private and not readily accessible to the public; and many are in metropolitan or industrialised countries that have had a colonial history in the tropics, in which case they are also not readily accessible to working specialists in tropical countries. Depositories consist of herbaria and museums for preserved material; zoos, botanical gardens and culture collections for live material conserved ex-situ; and protected areas for live material conserved in-situ. Repositories consist of indexes of collections and surveys, data banks and networks of information systems containing geographic, resource and environmental data. Depositories and repositories are important not only for authenticating material and information collected in surveys, but also for the holding of material and information about it and promoting its use in the search alternative livelihoods.

Inadequate information was available to examine this range of institutions. For example, the nine international agricultural research institutions of the Consultative Group on International Agricultural Research [CGIAR] concerned with staple crops and species hold and test a germplasm collection of about 420,000 at a cost of about US$200 million a year; and this is coordinated by a tenth institution, the International Board on Plant Genetic Resources [IBPGR]. In spite of this massive effort, most of the wild relatives of these major crops and species have not been collected [Hoyt 1988], and therefore need to be protected in-situ. Similar information is required for other forms of living and preserved collections of genetic and species variability. In the Food and Agriculture Organization of the UN [FAO], important work on genetic resources and species adaptability has been carried out by the Plant Production and Protection Division and the Forest Resources Division, and to a lesser extent by the Animal Production and Health Division and the Fishery Resources and Environment Division, at an estimated cost of US11.5 million per annum. For plants, there is an international legal undertaking with a Commission on Plant Genetic Resources made up of 114 countries. This Commission promotes [1] a network of base collections, [2] a global information and early warning system, [3] a network of in-situ protected areas, and [4] the Tropical Forest Action Plan. It provides an international forum for donors and

users of germplasm, an international fund to promote conservation and use of germplasm, and coordination between governmental and private institutions and between plant breeders and farmers. Under its auspices, for example, a systematic set of priorities is developed every five years by an Expert Panel on Forest Genetic Resources, to review regions and species in relation to:

* their importance for specified end uses [industrial wood and pulp, fuelwood and energy, and other structural and chemical uses] on a three-point scale [highest, considerable and some actual importance]; and

* their operational priority [urgent, within a biennium, within a quinquennium, and completed] in terms of exploration [botanical, genecology], evaluation [collection, testing], conservation [in-situ, seeds, ex-situ] and utilization [bulk supplies, individual selection and breeding]

Through such a review mechanism involving the collaboration of all countries and their institutions, the FAO Forest Resources Division spends about US$400,000 a year on seed procurement [US$85,000], ex-situ conservation [$10,000], in-situ conservation [$60,000], information dissemination [$95,000] and on directory management [$150,000]. Furthermore, the Panel has identified global conservation priorities in terms of fuelwood, food, fodder and multipurpose species, species for arid and semi-arid regions, nitrogen-fixing species and species of special importance [bamboos, rattans, mangroves], and endangered species endemic on islands. A methodology has been developed for a broad approach to conserving forest genetic resources in this manner [FAO 1975], which could be adapted for other areas of genetic and species diversity of importance to human well-being.

The classification of habitats and ecosystems based on species associations and biotopes is still inadequate for the tropics and the marine environment. It is difficult to develop especially in areas of high diversity where taxonomic uncertainties prevail. Nevertheless, it is needed for characterising spatial areas used for in-situ and ex-situ conservation. The World Conservation Union [IUCN 1983] has devised 10 categories of protected areas based on objectives and criteria:

I Scientific Reserve, Strict Nature Reserve
II National Park
III Natural Monument, National Landmark
IV Nature Conservation Reserve, Managed Nature Reserve, Wildlife Sanctuary
V Protected Landscape
VI Resource Reserve
VII Natural Biotic Area, Anthropological Area
VIII Multiple Use Management Area, Managed Resource Area
IX Biosphere Reserve
X World Heritage Site [Natural]

These protected areas have not been assessed in terms of their habitat and ecosystem diversity, and the genetic and species diversity they contain. There is a need to test these protected areas for biological diversity based on biogeographic theory [Wilson 1988]. Roche and Dourojeanni [1984] have assessed their suitability for conserving genetic, species, and habitat and ecosystems diversity in the tropics on a five-point scale using experts with experience in the tropics [Table 6]. Four categories of protected areas appears best suited for conservation of genetic and species diversity: National Parks [II], Managed Resource Areas [VIII], Managed Nature Reserve [IV] and Strict Nature Reserve [I]; and among the managed nature reserves [IV], the best are the production and protection forest reserves, and the fauna reserves. Protected areas need to be carefully studied as in-situ depositories of biological diversity, since most of them are small and therefore prone to degradation.

Depositories of and repositories on biological diversity are relatively easy to establish but difficult to maintain. For example, while depositories of global significance like the Herbarium of the Singapore Botanical Gardens and the zoological collection of the Raffles Museum in Singapore are being maintained, they are barely being used in the survey of biological diversity of the region. **There is a need to assess the state of depositories curating genetic and species diversity ex-situ, and [of protected areas] harbouring unique and representative habitats and ecosystems in-situ especially in tropical and marine environments; as well as of repositories holding information on biological diversity at different levels.**

Depositories and repositories are expensive institutions to maintain. The International Board on Plant Genetic Resources spends about US$20-25 million per annum on maintaining its germplasm collection. The cost of establishing a gene bank for India was about US$10 million and involved support from the Ua.S. Agency for International Development; whereas the cost of a regional gene bank for Southern Africa amounts to US$12 million per year for 20 years with support from the Nordic countries. The collation, evaluation, storage and dissemination of conservation information by the World Conservation Monitoring Centre [WCMC] costs about US$1.7 million per annum, with the Centre using a network approach to store environmental and resource information on a geographic basis. On the basis of the availability of US$0.25 million per country to revive its sites and institutions, the initial cost of technical assistance for depositories and repositories could be about US$30 million per annum.

Table 6: Evaluation of Protected Area Categories for Genetic, Species and Habitat Diversity Conservation

CATEGORIES: CRITERIA:	I	II	III	IV	V	VI	VII	VIII	IX	X
Representative of biodiversity	4	5	1	3	1	3	2	3	2	1
Representative of rare or endangered species	5	4	2	3	1	3	2	3	3	2
Area of nation	1	4	1	3	1	3	3	5	1	1
Application in the tropics	3	5	2	5	1	4	4	5	2	2
Effective conservation status	5	5	3	5	1	1	1	3	3	5
Potential for effective management	1	2	1	4	5	3	4	5	3	1
TOTAL	19	25	10	23	10	17	16	24	14	12

SOURCE: Roche and Dourojeanni [1984]

3.2.9 Socio-Economic Research

Conservation of biological diversity is hardly incorporated into the "cost-benefit" analysis of development projects. In being treated as an externality, biological diversity is often overlooked because of difficulties in its quantification and monetisation. Even impact assessment procedures do not often take account of the state of biological diversity in tropical and marine environments because of problems of taxonomic uncertainty. There is a need to explore ways of expanding the "cost-benefit" approach to accommodate impacts on and trade-offs of biological diversity in terms of:

* **Costs and benefits**: maximising net gains to human welfare during the life-cycle of the resource by listing of all gains and losses, quantifying wherever possible and monetising as much as possible;

* **"Distributional" objectives**: by income and social categories especially of disadvantaged communities;

* **"Spatial" equity**: or benefits to particular regions; and

* **"Developmental" objectives:** as instruments of dynamic change at local, provincial or national levels.

Innovations in technology for intervening in ecological processes and transforming natural resources into goods and services for human welfare have out-stripped human capability in management. As a consequence, biological diversity is being directly and indirectly destroyed or degraded. Technological interventions which cause the degradation and destruction of biological diversity are not only large-scale but, also, small-scale. There is no standardised approach for classifying impacts of technology and for measuring the magnitude of their effects against some standards, in order to facilitate comparison of development and conservation aspects of projects, and promote the exchange of experiences. **There is a need therefore for a standard international approach for assessing the effects of various technologies threatening biological diversity, and for promoting an exchange of experiences, and for enabling integrated assessments of biological diversity based on their multiple outputs or benefits [e.g. energy, food, industrial materials] using an expanded "cost-benefit" approach.**

There were no cost estimates available for socio-economic research, except for the US$0.5 million per annum in Chile for assessing heritage areas. On the basis of the availability of US$0.25 million per country for surveys and technical assistance, the cost estimate for socio-economic research could be about US$30 million.

3.2.10 Education and Training

The most important constraint to the conservation of biological diversity on a regional global scale is the shortage of skilled expertise in various facets of the problem especially in the tropics and in the marine environment. This is particularly the case with developing countries in the tropics. **There is a need therefore to give training of technical expertise in taxonomy and classification, autecology and community ecology, curation and husbandry, information storage and retrieval, and in survey and monitoring techniques, a high priority for the conservation of biological diversity.** In Chile the needs for education and training have been estimated at US$0.65 million per annum, while in Denmark expenditure on conservation education and training is about US$1 million per annum. The need for an additional 7,500 taxonomists alone would cost about US$340 million. Realising that this is an important area, the estimate for initiating education and training could be about US$100 million per annum.

3.2.11 Management Strategies and Plans

Government and inter-governmental administrations are well organised already according to development sectors which are the source of environmental and social impacts affecting the conservation of biological diversity. They already spend vast sums of money managing protected areas. For example, Denmark spends about US$3.5 million per annum on managing its protected areas, Chile about US$6 million per annum and Finland about US$7 million per annum. The Food and Agriculture Organization of UN spends about US$21 million per annum on protected areas management. Management strategies and plans should concern not only areas rich in biological diversity, but also those areas under threat. The World Conservation Union [IUCN] has been promoting national conservation strategies in many countries to take stock of environment and development issues; and such plans need to be taken forward to implementation with the involvement of the development sectors in protecting and rehabilitating their resource and environment base. **It would be effective therefore to enlist the involvement of the development sectors in regulating their activities by expanding their scope and coordinating their work in conserving biological diversity.** On the basis of the availability of technical assistance US$0.5 million per country and region per annum, the cost estimate for stimulating management strategies and plans could be at least US$75 million per annum.

3.2.12 Monitoring

Effective regional action plans will require monitoring and evaluation of actions taken to conserve biological diversity. The Global Environment Monitoring System [GEMS] has been established under the United Nations Environment Programme to undertake this task. It works effectively through national and international networks which are concerned with one of the following elements:

* Environmental pollutants
* Long-range transport of pollutants and their effects such as acid rain
* Marine pollutants and living marine resources
* Climate and atmosphere
* Renewable natural resources.

A geographical data management system, the Global Resource Information Database [GRID] integrates data-sets to address specific environmental problems; and regional nodes for data management are being established, which should facilitate regional action plans for conservation. The World Conservation Monitoring Centre [WCMC] is a network node for data on biodiversity by species, areas and trade. It captures, manages and disseminates data and works with its network partners to verify data. The WCMC has a budget of about US$1.7 million a year half of which are its operational costs, and a quarter of which are connected to specific projects. This kind of system can help to make projections

for areas lacking or possessing unreliable data. For example, the GEMS network facilitated the development of the estimate that a population of 1 million elephants in Africa at a growth rate of 5% per year could be expected to produce a harvest of 400 tonnes of tusks per year. This kind of information is very important for the conservation of biological diversity. **There is a need to ensure that an information management system is integrated into the regional action plan.**

Data bases are expensive to maintain and modernise. The International Whaling Commission spends about US$1 million per annum in monitoring the whale stocks; and Denmark spends about US$1 million per annum monitoring the protected areas and the environment. On the basis of technical assistance being available at US$0.25 million per country and US$1-2 million per region per annum, the additional cost of monitoring biological diversity could be about US$100 million per annum.

3.2.13 Conservation and Sustainable Technologies

Regional action plans will need to survey, identify and document innovations in conservation technology at the local level especially those that are sustainable, so that they may be demonstrated widely within countries and regions. There were no cost estimates available for this item. However, studies and technical assistance on conservation technologies could cost at least US$20 million per annum.

3.2.14 Priority Projects

The regional action plans should include projects demonstrating conservation of biological diversity in rich and poor terrestrial and aquatic environments. There were no estimates available for such items. Such projects should be organised on a regional basis to allow for inter-comparisons, and could initially need about US$40-50 million per annum.

3.3 Benefit to Local and Indigenous Populations

The regional action plans should be used to benefit local, particularly indigenous, populations. This could take the form of studies and technical assistance on the rights of indigenous peoples, on documenting traditions transmitted orally, and priority projects demonstrating the modernisation of technologies used in sustainable harvests. Such plans need to have two basic ingredients in order to ensure benefits to local and indigenous populations:

[1] Focus on Traditional Approaches: Involvement of the local and indigenous communities in regional action plans on conservation of biological diversity can provide new information of value to the public. This is particularly true where traditional knowledge has been orally transmitted. To make the action plans relevant locally and regionally, they could address one or more of the following issues concerning plants, for example:

* Location of traditionally-valued plants;
* Traditional uses of these plants for food, clothing, shelter, medicines, etc;
* Traditional ways of growing and harvesting these plants;
* Traditional ways of preparing these plants for different uses; and
* Biochemical assays of the active ingredients of these plants.

[2] **Balanced Management**: Local and indigenous communities are usually disadvantaged in comparison to urban and industrial interest groups in terms of organisation and access to political power. Their interests must therefore be managed sensitively and in a balanced manner, so that they too benefit from conservation and development programmes. The precise nature of their involvement and benefit would have to be examined in detail at a national and regional level.

There were no estimates available for the cost of this item. On the basis of US$0.9 million per annum spent on the rights of indigenous peoples in Chile, the additional funds required for studies, technical assistance and priority projects involving indigenous people could be around US$100 million per year.

3.4 Emergency Action Plan for Protected Areas

3.4.1 Protected Areas System

A global strategy for conserving biological diversity should incorporate an emergency action plan for protected areas that require special attention, since many of these are threatened by their small size. Emergency action could take the form of surveys of threatened species and small and threatened areas, restoration and rehabilitation of degraded areas, and management plans for threatened areas. There was little information available on this subject. The World Conservation Union's 10 categories of protected areas are being aggregated into six in a revised framework [Table 7] in which their conservation objectives have been defined clearly [Table 8] [Eidsvik 1990]. There is a need for an ecological evaluation of these revised categories in relation to both biophysical and socio-cultural processes. Collectively, 4,545 sites have been protected covering 4.85 million sq km [Table 9], which constitutes 3.7% of the land area. Most of these sites are small and therefore prone to "edge" effects and erosion

of biological diversity. Their value for conserving biological diversity in the tropics has been questioned [see earlier]; and needs review in relation to biophysical and socio-cultural processes that make them sustainable [Table 10] [NRC 1989]. Tropical terrestrial and marine habitats and ecosystem types are inadequately represented among these protected areas, most of which have not been properly surveyed. It has been estimated that the management of these protected areas cost about US$200 million per year [H.E. Eidsvik, pers. comm.] which is low at US$40 per sq km in comparison to US$3,000 per sq km for restoring degraded lands in Europe and US$400 per sq km for managing rhinoceros habitat in Africa. There is a need therefore to **assess the protected areas in the tropical and marine environments in relation to the ecological and socio-cultural processes that enable them conserve biological diversity, and to hierarchical linkages that could make them useful for global monitoring like the Biosphere Reserves.**

3.4.2 Restoration of Degraded Areas

Most protected areas in the tropics and in the marine coastal zone are of small size [below 25 sq km] and hence prone to degradation. There is a need to **rehabilitate them in as flexible a manner as possible** [Table 11] [A. Lugo in Hadley and Schreckenberg 1989]. Rehabilitation and restoration of degraded areas is expensive. In Denmark about US$10 million is spent per annum on restoration of degraded areas, and a further US$3.5 million per annum on the management of threatened areas. The cost of rehabilitating Madagascar is about US$6 million per annum over 20 years. Landscape and seascape rehabilitation and restoration is thus an expensive proposition.

3.4.3 New Protected Areas

The tropics and the marine environment are particularly under-represented in the system of protected areas. There is a need to establish new protected areas in these environments especially in relation to an examination of these biomes on a species association basis, so that at least 10% of their area is protected for conserving biological diversity.

The costs of an emergency action plan for protected areas are difficult to estimate. Based on the need for rehabilitating Madagascar at US$6 million per year over 20 years and the expenditure of US$10 million per year in landscape rehabilitation in Denmark, there is a need for hundreds of millions to units of billions US$ for the emergency action plan.

Table 7: A Framework for Conservation Areas

CATEGORIES & GENERIC NAMES [and special designations] R= Reserve, P= Park A= Area, S=Sanctuary	HUMAN INTERVENTION			RECOGNITION & LEGAL STATUS		
	Low 0-10%	Mod 11-30%	High 31-50%	Private Local Institutional	Provincial	National
I SCIENTIFIC RESERVES	++++++					
Strict Nature R	++			+	+	+
Ecological R	++++			+	+	+
Biogenetic R	++			+	+	+
Marine Sanctuaries	+++++			+	+	+
II WILDERNESS, NATIONAL PARKS & EQUIVALENT R	++++++++++					
Wilderness Areas	++++				+	+
National Parks	+++++					+
State/Provincial P	++++++				+	+
Local/Tribal Parks	++++++++			+		+
Marine Protected A	+++++++++					+
III NATURAL & CULTURAL FEATURES	++++++++					
Geological Features & Fossil Beds	++			+	+	+
Natural Landmarks	+++++			+	+	+
Native Heritage A	++++++			+	+	+
Battle Fields & Archaeological Site	++++++			+	+	+
IV HABITAT & WILDLIFE MANAGEMENT AREAS	++++++++++++					
Nature & Bird S	+++++++				+	+
Wildlife Ranching A		++++++		+	+	+
Wetlands & Refuges	++++++++++			+	+	+
Marine Management A	++++++++++			+	+	+
V ECODEVELOPMENT	++++++++++					
Protected Landscape		++++++			+	+
Seashores	++++++++				+	+
Scenic River, Trail & Waterways	+++++++++				+	+
Regional Nature P	+++++++				+	+
Recreation Areas		+++++			+	+
Landscape Conservation		++++++		+	+	+
Forest Reserves		++++++		+	+	+
VI INTERNATIONAL DESIGNATION	++++++++++					
World Heritage Site	++++++			+	+	+
Ramsar Site		++++++++			+	+
Biosphere Reserves	+++++++++				+	+

Table 8: Primary Conservation Objectives of Protected Areas

	AREAS: / OBJECTIVES:	I	II	III	IV	V	VI
A	Maintain Essential Ecological Processes and Life-Support Systems	1	1	2	2	2	1
B	Preserve Genetic and Species Diversity	1	1	2	1	2	1
C	Protect Aesthetic Values & Natural Ecosystems	2	1	1	2	1	1
D	Conserve Watersheds and their Production	3	2	3	3	2	2
E	Control Erosion, Sedimentation and Soil Depletion	3	3[W] 2[P]	3	3	2	2
F	Protect Habitat or Representatives of Rare and Endangered Species	2	1	2	1	1	1
G	Provide Opportunities for Ecotourism	3	3[W] 2[P]	3	2	1	2
H	Provide Opportunities for Research, Education and Monitoring	1	1	2	1	1	1
I	Stimulate Sustainable Use and Ecodevelopment	3	3[W] 2[P]	3	2	1	2
J	Protect Natural and Cultural Heritage	2	1	1	2	1	1

AREAS: I = Scientific Reserves, II = Wilderness, National Parks and Equivalent Areas, III = Natural and Cultural Features, IV = Habitat and Wildlife Management Areas, V = Ecodevelopment, and VI = International designation

OBJECTIVES: 1 = Primary Objective for Establishment and Management, 2 = A Secondary Objective but not always Included, 3 = Included as an Objective where Feasible and not in Conflict with 1 or 2

W = Wilderness Area, P = Parks

SOURCE: Eidsvik [1990].

Table 9: Protected Areas of the World

REALM	NO. OF SITES	AREA [sq km]
AFROTROPICAL	444	860,900
INDOMALAYAN	676	322,800
PALAEARCTIC	1,684	731,900
OCEANIAN	52	48,900
NEARCTIC	478	1,725,600
NEOTROPICAL	458	768,100
AUSTRALIAN	623	356,900
ANTARCTIC	130	31,200
TOTAL	4,545	4,846,300

SOURCE: McNeely, Miller, Reid, Mittermeier and Werner [1990]

Table 10: Criteria for Protected Areas

CRITERIA	CHARACTERISTICS
	[A] BIOLOGICAL
1 DIVERSITY	species, communities, habitats & ecosystems except pioneer communities, and climax communities of disrupted areas [e.g. shore]
2 NATURALNESS	lacking disturbance or degradation; of value to tourism and productive use, and to restoration of degraded areas
3 DEPENDENCE	on habitats and ecosystems, on ecological processes, edge effects and ecotones
4 REPRESENTATIVE-NESS	of habitats, communities, ecological processes and natural features
5 UNIQUENESS	of species, habitats and ecosystems; of regional and international significance
6 INTEGRITY	of ecological functions; self-sustaining
7 PRODUCTIVITY	of species and communities except eutrophic
8 VULNERABILITY	to degradation due to low stress tolerance

Table 10 [contd]

		[B] SOCIAL
9	SOCIAL ACCEPTANCE	supported by local human communities, by their traditions and rituals
10	CULTURAL ATTRIBUTES	of religious, historic and artistic significance
11	CONFLICTS OF INTERESTS	in human use [e.g. commercial harvests] requiring zoning
12	BENCHMARK POTENTIAL	as a control for measuring anthropogenic changes elsewhere [e.g. biosphere reserves]
13	EDUCATION POTENTIAL	for research and demonstration of species, habitats and ecological relationships]
		[C] ECONOMIC
14	IMPORTANT SPECIES	for breeding, resting or feeding of species of economic importance; hence zoning
15	LOCAL RESOURCE ECONOMY	dependence of local economic livelihood and size of harvest; hence sustainable yield
16	THREAT MAGNITUDE	from changes in use pattern [habitat or technologies] causing overexploitation of species with low breeding potential
17	ECONOMIC BENEFITS	of protection or restricted use to local and external economies
		[D] MANAGEMENT
18	EFFECTIVENESS	of patrol, monitoring and protection
19	OPPORTUNISTIC	reinforcing existing conditions and actions [e.g. extension of protected area]
20	AVAILABILITY	for protection and management with the agreement of owners, or by acquiring tenure

SOURCE: NRC [1989].

Table 11: Strategies for Rehabilitating Degraded Tropical Forests

* Maintain flexibility in the rehabilitation approach
* Be alert to environmental conditions
* Avoid specificity on the ultimate goals of rehabilitation
* Maximise vegetation cover
* Manipulate existing vegetation before attempting a substitution
* Use fallow to do most of the forest rehabilitation
* Restore tree cover as quickly as possible
* Be aware that nutrient cycling strategies may change through rehabilitation from phosphorus limitation to nitrogen limitation
* Develop species mixtures [associations] depending on their "ecological" combining ability
* Keep topsoil moist, cool and shaded
* Couple ecosystems to maximise their value, and accelerate rehabilitation [e.g. use treated urban sewage as irrigation water to accelerate tree growth]
* Maximise ecosystem complexity to optimise use of site resources, maximise protection from pests and diseases, and to minimise risks
* Use exotic tree species to foster native species through site rehabilitation
* Use multiple seeding techniques when in doubt as to what to plant, and let natural selection processes decide the best species combination for a site
* Create loci of species activity from which habitat rehabilitation occurs under the influence of biotic agents
* Use stressors to arrest succession at a desirable stage

SOURCE: A. Lugo in Hadley and Schreckenberg [1989].

3.5 Biological Diversity Research

Any global strategy for conserving biological diversity should consider support for research of value to management and to harnessing new information for economic growth and alternative livelihoods. There is need in particular to identify research on biological diversity in the tropics outside the main band of species currently exploited. This research process will involve identification, verification and authentication of biological diversity, promotion of its economic uses, and development of its sustainable uses. The literature available on this topic was limited.

Biological diversity research should be aimed essentially to address management issues concerning the ecological processes sustaining genetic, species and habitat and ecosystem variability [see earlier]. Research focus on questions of importance to management is particularly needed in view of the escalating threats to conservation:

* Genetic and species losses due to habitat fragmentation, modification or consolidation;

* Redundancies and compensations of species diversity at large scales in carbon, nutrient and hydrological cycles;

* Role of habitat and ecosystem diversity and fragmentation [mosaics] in landscape functioning;

* Role of species assemblages as indicators of environmental changes;

* Role of species associations in changing system dynamics;

* Species and functional diversity at land-water and lowland-highland interfaces; and

* Scaling of species interactions and ecosystem and landscape functions.

Four themes should be considered in this research programme [di Castri and Younes 1989]:

[1] The relation between species and landscape or seascape diversity with respect to change:

This research theme should enable understanding of the role of disturbances on the structure and function of habitats, ecosystems and landscapes or seascapes at different spatial scales in relation to genetic and species diversity, especially in the tropics and in transitional zones [e.g. land-water ecotones, estuaries and the Mediterranean]. The null hypothesis being tested should be that genetic and species diversity are more

important at micro- or small scales than at meso- or large scales because of buffering and compensatory effects in the latter. The approach taken to understand these relationships should be that of using comparative river basins, or landscape or seascape units with reference to:

* species diversity, demography and biogeography;

* inter-specific interactions, both positive and negative, especially in terms of edge effects and ecotones;

* sources and sinks for water, minerals and gases, especially on the role of microorganisms in nutrient entrapment, nitrogen fixation, decomposition, soil and water quality, symbiosis and environmental detoxification; and

* productivity.

[2] Global biogeographic classification system:

This research theme should enable the development of a standard global biogeographic classification system for comparing and contrasting ecosystems and landscapes or seascapes, and for identifying unique and representative areas, in relation to change. The null hypothesis being tested should be that species diversity is strongly correlated to ecological processes at landscape levels, at different spatial and temporal scales [suggesting hierarchical levels] and in indicating environmental changes at the regional or meso-scale. The approach needed to understand these relationships should be that of using a hierarchical network of observatories, ecological patterns for assessing habitat loss and species associations as indicators of ecological processes, with reference to:

* small discontinuous areas with low species diversity [e.g. lakes, islands, oases];

* large but patchy areas with rich species diversity [e.g. lowland forests, continental shelves, land-water ecotones]; and

* large areas with relatively even species diversity [e.g. open seas and oceans, tundra].

[3] Species diversity as long-term indicators of change:

This research theme should enable the understanding of changes in species diversity in relation to changing habitats and landscapes over time, to land use, fragmentation and gradients, to ecosystem functions, and to habitat losses, pollution, invasions and epidemics. The null hypothesis being tested should be that there are very few historical and reliable data sets to facilitate understanding of global change. The approach needed to understand

these changes is a focus on major land- and sea-scapes by institutions having secured support, historical data sets and an ability for undertaking integrated research, with respect to:

* Population and community structure; and

* Ecosystem functions particularly productivity, material fluxes, climatic variations, hydrological cycles and substrate changes.

[4] Effective conservation of genetic resources of wild species:

This research theme should focus on the conservation of germplasm of wild relatives of species of potential economic value. The null hypothesis being tested should be that protected areas have been assumed to safeguard the germplasm of useful species, but their effectiveness has never been assessed. The approach taken in this study should be to understand the relationship of protected areas to their effectiveness in protecting biological diversity, to the appropriateness of their management systems, and to the effectiveness of small populations and networks of complementary ex-situ germplasm centres, with respect to:

* Rare and endangered species;

* Species of economic importance;

* Species of value in ecosystem restoration and rehabilitation; and

* Isolated species.

Research on biological diversity conservation should thus focus on under-utilised and marginal species, on species associations and community types, and on landscape mosaics. It should be undertaken through international collaboration, and linked to the International Geosphere-Biosphere Programme [IGBP] which currently does not focus on the conservation of biological diversity, nor involves the developing countries in any significant manner [only 3/24 participating countries are developing].

Some ingredients of collaborative interdisciplinary research have been outlined by Swift [1984]. Such research should address socio-economic issues since biodiversity conservation can be beneficial as in the case of Canadian bird conservation [Table 12]. It is difficult to cost biodiversity research without detailed consideration of the issues being studied and consultations with potential partners, but indicative unit costs may be helpful [Table 13]. American non-governmental institutions currently support biodiversity research and training amounting to US$37 million per year. The U.S. Agency for International Development has been mandated to increase its allocation for biodiversity research. The U.S. National Science Foundation has agreed to allocate additional resources for biodiversity research and training as follows [NSF 1989]:

* Inventory: US$5 million per year rising to $20 million; Microorganisms US$8 million per year rising to another $20 million; Ecological research at US$5 million per year;

* Conservation Biology, Restoration Ecology and Environmental Management: US$3.5 million per year rising to $10 million;

* Education and Public Awareness;

* Socio-Economic Aspects of Biodiversity Conservation: US$1 million per year; and

* Research and Management in Developing Countries: US$2 million per year.

The Food and Agriculture Organization of UN spends at least US$300 million per annum on testing and breeding programmes; and the Consultative Group for International Agricultural Research spends another US$200 million per annum. On the basis of these estimates, it would be reasonable to expect an additional US$100-300 million per annum for broadening the use of species diversity authenticated, and for conserving biological diversity.

Table 12: Economic Value of Canadian Birds especially Waterfowl, 1981 [C$ 1981]

ITEMS	ALL WILDLIFE	WATERFOWL & BIRDS
Participants	41 million	16 million
Direct economic benefits [Net annual value]	$779 million	$347 million
Capitalised Value [@ 5% discount rate]	$15.6 billion	$6.9 billion
Expenditures by Participants/Year	$4.2 million	$2.0 million
Gross Business Product per year	$8.8 billion	$4.1 billion
Gross Domestic Product per year	$5.2 billion	$2.4 billion
Personal Income per Year	$3.0 billion	$1.4 billion
Government Revenue per Year [Taxes]	$1.9 billion	$870 million
Employment per Year	185,000	86,000

SOURCE: Filion [1987], Jacquemot and Filion [1987]

Table 13: Unit Costs for Biodiversity Research

ITEMS	COSTS [US$/Year]
Technical Assistance	$ 12,000
Research Grants	$ 50,000
Information Management & Evaluation	$200,000
Wildlands Demonstration Project	$ 50,000
Pilot Conservation Data Centres	$150,000
Demonstration Protected Areas	$150,000
Demonstration Buffer Zones to Protected Area	$200,000
Pilot Conservation Education Project	$100,000
Technical Assistance for Research & Training	$300,000
Support for Local Economic Analysis	$100,000

3.6 Traditional Uses of Biological Diversity

A global strategy should include an assessment into the ways in which indigenous people harvest useful substances from tropical wild lands and waters on a sustainable basis. Traditional knowledge has been used to harvest of useful substances from natural biological diversity at different intensities causing low level perturbations. Materials harvested thus have been used for fuel, staple food [carbohydrates, proteins, water], food supplements [minerals, vitamins], beverages, psychedelics, medicines, clothing and construction materials. A variety of technologies have been used traditionally to harvest the desired products often in association with profound spiritual rituals for conserving the resource. Understanding the cultural context of this process has potentially profound value to the evolution of the conservation ethos. In plants for example, these technologies take the form of pruning and coppicing, using seeds and fruits and bark, collecting resins and secretions, tapping, using whole organisms, burning and planting and culturing. **Six steps are necessary in order to conserve cultural diversity and benefit from it:**

[1] Giving appropriate value to the traditional rights, knowledge and skills of indigenous peoples;

[2] Taking special measures to protect the rights of indigenous peoples;

[3] Providing information on traditional resource management systems;

[4] Promoting the application of traditional wisdom to modern resource management;

[5] Designing projects which benefit indigenous peoples; and

[6] Designing projects which benefit from traditional knowledge.

There were no estimates available for this item in the strategy. On the basis of an availability of US$2-5 million per annum for each region, the cost of additional funds to research into the ways in which indigenous people harvest useful substances could be in the low hundreds of million US$.

3.7 Patent Protection and Technology Transfer

A global strategy for conserving biological diversity should include the cost of obtaining patent protection for new medicines and other chemicals derived from tropical species, and the cost of technology transfer. Discoveries of new products and processes where patent protection is useful occur at a very low rate of 1/100 or 1/1000 where mass screening techniques are used. In selective screening techniques involving considerable knowledge and experience, the success rate of discovering interesting compounds may be as high as 1/10. While it is advantageous to patent new products or processes, experience has shown:

[1] that very few of the patents are actually used, thereby casting a shadow of doubt on the utility of patenting; and

[2] that where useful patents have been struck, they are bought by more advanced institutions, deciphered and replaced by new and enhanced patents.

Patent protection is thus complicated and requires sophisticated scientific and legal know-how if developing tropical countries are to benefit from them.

While plant breeders' varieties are protected by patenting and organisations like the International Union for the Protection of New Varieties of Plants [UPOV], the traditional source of variability has been somewhat overlooked hitherto. 90% of new varieties are from developing countries in the tropics where farmers and indigenous peoples have contributed to their selection over millennia [Mooney 1983]. 25% of the pharmaceuticals sold today are of plant origin and generate expenditures in R&D of the order of US$4 billion a year, and sales of the order of US$8 billion a year. The total contribution of wild germplasm to the America economy, for example, has been estimated to be US$66 billion, with a wild tomato from Peru alone contributing US$8 million a year; and drugs from the Madagascar periwinkle alone generating sales of US$160 million a year. The farmers' rights have therefore been adopted by the 158 countries of the Food and Agriculture Organization of the UN. It establishes an International Fund of about US$500 million through a levy on commercial patents derived from germplasm collected from farmers in the developing countries of the tropics. It costs a fraction of US$1 million to secure a good comprehensive patent protection. Where

biotechnological advances have been made on the access to germplasm of tropical species, there will be need to develop some mechanism for compensating the natural source of the original genetic material, and even promoting the transfer of technology. On the basis of US$1-5 million per annum being available per region, additional funds of at least US$100 million would be required for promoting patent protection and technology transfer in tropical developing countries.

4 CONCLUSIONS

A global strategy for conserving biological diversity especially in the tropics and in the marine environment should be developed in view of serious and emerging threats to it. One of these threats is the high population and economic growth rate of tropical developing countries which is potentially destabilising and which exhibits little sign of slowing down. Additional funds should be secured and targeted for conserving biological diversity and promoting the search for alternative economic livelihoods for people in these countries. An estimate in the high hundreds to units of millions US$ needs to be secured for implementing such a global strategy.

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ANNEX

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Current Multilateral, Bilateral and National Financial Support for Biological Diversity Conservation*

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* A study prepared by A. Markandya, MetroEconomica Ltd. (London, U.K.). It has been reproduced without formal editing

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CURRENT MULTILATERAL, BILATERAL AND NATIONAL FINANCIAL SUPPORT FOR BIOLOGICAL DIVERSITY CONSERVATION

A Case Study

Prepared for UNEP

by

Dr. A. Markandya

Metroeconomica Ltd

London UK

June 1990.

I. INTRODUCTION

Terms of Reference

1.1 At the second session of the Ad Hoc Working Group of Experts on Biological Diversity held in Geneva in February of this year, several areas of basic conservation needs were identified. In order to meet these, it was argued that a new legal instrument in the form of an encompassing convention would be required. Moreover, this would have to be supported by additional international resources; because the capacity of the governments facing the most serious conservation tasks (the developing countries) to allocate domestic resources was extremely limited, and because the benefits of the conservation activities extended beyond national boundaries and were, indeed, often truly international.

1.2 To make suitable recommendations on the nature of the financial mechanisms and the legal instruments required for this purpose, the Working Group identified the need for a study to determine the real funding requirements for global conservation needs, taking into account the level of funding currently provided by development and other assistance programmes for the purpose of conserving biological diversity in developing countries. In particular, the questions to be addressed were:

a) what is the current state of expenditure on conservation of biodiversity, and what are the sources and uses of these expenditures;
(b) what are the unmet conservation needs; and
(c) how might such needs be financed, via resources external and internal to a country?

1.3 This document is concerned with answering these questions. The present section begins by describing the problem of biodiversity, explaining why it is an issue of importance and examining the actions currently being taken to address the pressing conservation concerns that face the world today. In Section II, a more precise attempt is made to

estimate the allocations of resources to developing countries for conservation and biodiversity protection. There are many difficulties in carrying out such an exercise, and what has been achieved in this report is incomplete. Nevertheless it reveals some interesting data, and these are commented upon. Section III looks at the gaps left by the current range of activities to protect the biodiversity of the planet and asks what kinds of resources might be required for each of them, as well as where such resources could come from. Section IV tries to give an initial estimate of the required funds, indicates why these estimates are only rough first orders of magnitude at this stage, and points to the areas of further effort required if more precise estimates are to be obtained. There is an annex to the report listing the agencies contacted in connection with its preparation.

The Issue of Biodiversity Protection

1.4 The concern with biological diversity encompasses all species of plants, animals and microorganisms; and the ecosystems of which they are a part. It is usually considered at three levels: genetic diversity (variety within a species), species diversity (variations within living organisms) and ecosystem diversity (variety of habitats, biotic communities and ecological processes in the biosphere). Conservation is the maintenance and continuing evolution of a species. It implies, inter alia, that a population greater than the critical minimum should be maintained if the species is to be preserved in its natural habitat (i.e. in situ).

1.5 There is no accurate estimate of the total number of different living species on this planet. Figures range from 5 to 30 million, although only 1.4 million have been properly described. Plant species, which are of particular interest in the context of this report, number about 265,000. Of these 80,000 are in temperate zones and 185,000 in tropical regions. The rate of loss of these, especially from the tropics is quite alarming. On current estimates up to 130,000 could be lost from these areas over the next quarter of a century. By contrast only 8000 species are threatened

in temperate regions. Overall the rate of loss of biodiversity is a matter of serious concern: between 5 and 30 percent of existing species are threatened with extinction over the next 20-30 years, amounting to about 100 species a day. This rate of loss exceeds the historical rate of extinction by a factor of more than 1000.

1.6 Four main reasons have been identified for this loss of biodiversity. First is habitat modification. As forests are cleared, wetlands drained, valleys flooded and roads built, so habitats are transformed and effectively lost for certain species. In forests even selective logging damages habitats for certain species. In West Malaysia, taking 3% of a certain forest is believed to have led to a loss of half the tree species[1]. There is no doubt that the extent of biological diversity is positively correlated with the habitat area. Yet the rate of loss of tropical forests is continuing so that, each minute 40 hectares of the remaining billion hectares are cleared. Second is the overexploitation of resource base. Commercial harvesting has been a threat to many marine species, exploitation has been the cause of extinction of some large terrestrial animals, and giant tortoises and well known species like the African Elephant are under threat today. One estimate has concluded that about 15% of bird extinctions and a number of tree extinctions have been caused by overexploitation[2]. Third is chemical and global pollution. Pesticides like DDT affect populations of predatory birds, lead poisoning has led to the loss of the last of the Californian Condors and acid rain has resulted in the loss of a number of fish species in Northern European lakes. In addition, global warming is now threatening many habitats. A recent report submitted to the Intergovernmental Panel on Climate Change has warned that global warming could accelerate the rate of loss of forested

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[1] A.D. Johns [1985], "Selective Logging and Wildlife Conservation in Tropical Rainforests: Problems and Recommendations", Biological Conservation, 31: 355-375.

[2] M.E. Soulé (ed.) [1986], Conservation Biology: The Science of Scarcity and Diversity, Sunderland, MA: Sinauer Associates.

areas, and another study by the World Wildlife Fund for Nature suggests that rising sea levels could threaten almost all existing wetland in the world. Finally there is the impact of introduced species. This includes the impacts of diseases that have decimated populations, such as rinderpest that reduced the population of the African Buffalo by as much as 90%.[3]

Why Biodiversity Loss Matters

1.7 The reduction of biodiversity is a matter of concern because the rate of loss results in losses of benefits and because, carefully undertaken, programmes for conservation have been shown to have a value much greater than their costs. There are a several arguments as to why the present rate of loss of species is too great.

Biodiversity as a Public Good

1.8 First, there are a number of benefits from the existence of species that cannot be captured by those who manage or exploit them or are responsible for the habitats in which they are to be found. Such values arise from the pleasure many people get from the mere existence of species, such as the African Elephant or the Blue Whale, and there is considerable evidence to suggest that the numbers involved are very large[4]. Moreover, and what is relevant in the context of this study, the benefits accrue largely to citizens of rich nations, who are willing to pay considerable sums of money just to ensure the continued existence of

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[3] S. Barrett [1988], "Economic Guidelines for the Conservation of Biological Diversity", paper presented to the IUCN General Assembly, Costa Rica.

[4] See, for example, D. Pearce and A. Markandya [1989], Environment Policy Benefits: Monetary Evaluation, OECD, Paris. Pearce has estimated that, on the basis of existence values for species and habitats in rich countries, a value for tropical forests of $8 per person in the US and N. America would be conservative. On that basis a transfer to developing countries to conserve forests would be worth $3.2 billion per annum. See D. Pearce and J. Warford, [1990], Environment and Economic Development in the Third World, forthcoming.

certain species.

1.9 Because one cannot capture this willingness to pay for species, it is not possible to ensure that such benefits are taken into account in the calculus of costs and benefits that should determine how much a species should be exploited. In economic terms this facet of biodiversity is referred to as the international or global public good aspect. The same aspect is also responsible for insufficient attention being paid to conservation for other reasons. For example, the knowledge from the future exploitation of species in the form of new drugs or better varieties of agricultural products is also a public good[5]. Although one can patent certain processes and hybrid plants, thus rendering the benefits private rather than public, one cannot patent the species themselves[6]. Finally there are the general ecological benefits to be derived from conservation of habitats, such as microclimatic effects and improvements in water and air quality. These are also public goods, which impact on the local community rather than the international one.

Uncertainty of Benefits

1.10 Future benefits of conservation are uncertain and it is well known that the greater the uncertainty, the less willing private investors will be to undertake projects in the area concerned. However, what is uncertainty to the individual is not necessarily uncertainty to society as a whole. Hence even where resources could be preserved in a private context, such as ex situ germplasm, the level of such activity will be less than socially desirable. Certainly, significant gains have been made

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[5] Such values for future use of species to develop new products are referred to as option values. Options cannot be taken out for future use of resources and therefore one argument for conservation cannot be translated into money terms. This means that public support for conservation may be justified.

[6] See G. Brown Jr. [1985], "Valuation of Genetic Resources", mimeo., and W. Harrington and A.C. Fisher, [1982], "Endangered Species", in P.R. Portney (ed.) Current Issues in Natural Resource Policy, Resources for the Future, Washington DC, pp. 117-148.

from conservation activities in the past. It is estimated that about half the increase in productivity in agricultural yields in the US can be attributed to the use of plant genetic resources in breeding programs and many important drugs, such as the two most powerful anti-cancer drugs have been found in the biological resources of tropical forests. Again it is noteworthy that many of the benefits from this exploitation of species diversity comes to the developed countries.

Common Property

1.11 Many of the public good aspects of biodiversity are closely related to their common property feature. When there are no ownership rights, and when systems of common management and ownership break down, the incentives for continued maintenance are lost and even continued flow of private benefits is not guaranteed.

Government Policy

1.12 Finally government policy is as often as anything responsible for too rapid a rate of loss of biodiversity. Although markets do not function to protect biodiversity perfectly, they would, in some cases, do better if they were actually allowed to function. It is often because of distorting government incentives that forest clearance takes place. The usual form of such incentives is via tax credits for clearance that can be offset against income tax and subsidised credits for livestock farming. As a result of these, the commercial benefits of conservation cannot compete against clearance. It should be noted that the former are considerable, especially when non timber values are included. Indeed some studies have shown that conservation might be financially justified if such benefits could be commercially exploited[7].

1.13 In the light of the above arguments, it is clear that not enough would be done to conserve existing resources in the absence of government intervention, although it has to be recognized that some aspects of

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[7] See for example, C. Peters et al., [1989], "Valuation of an Amazonian Rainforest", Nature, 39: 655-656.

government policy, particularly in the field of fiscal policy can be as damaging to the environment in general and biodiversity in particular as anything else. A second point of importance is that, since issues are often global, the agreements of governments at an international level is necessary. Finally, the costs and benefits of actions are sufficiently unequal as to require a transfer of resources from the richer to the poorer countries of the world. The next section examines the major areas where such agreement have taken place and tries to estimate the amount of resources being transferred to Third World countries for the purposes of biodiversity conservation.

II. CURRENT SUPPORT FOR BIODIVERSITY CONSERVATION IN DEVELOPING COUNTRIES

2.1 Four types of action have been taken to support biodiversity conservation in developing countries:

(a) measures to protect particular habitat, such as wetlands, biosphere reserves etc;
(b) measures to protect particular species *in situ*;
(c) measures to conserve species *ex situ* - i.e. through captive breeding, gene banks etc; and
(d) measures to curb the contamination of the biosphere with pollutants.

2.2 In some cases these measures are organized through international conventions which, in turn, act through international development banks, through international organizations, through the efforts of the governments themselves, and through the participation of non-governmental organizations. In other cases these institutions and groups act without the benefit of a convention as such, but with specific conservation goals in mind. As far as conventions are concerned the major relevant ones to the problems of biodiversity in developing countries are shown in the box below. Excluded from this list are the many international agreements to limit biosphere pollution, such as the Montreal Protocol to Protect the Ozone Layer. Although such agreements have an impact on biodiversity, it is not the main aim of such conventions and their budgets are largely determined with other considerations in mind.

2.3 The activities of these conventions are largely organized by the contracting parties themselves, with the secretariats being concerned with the tasks of coordination, dissemination of information and, in some limited cases, research. For example, the RAMSAR convention, which is one of the most important in the field of habitat protection, relies on local resources to implement the protection of designated sites. Since many of

CONVENTIONS ON BIODIVERSITY RELEVANT TO DEVELOPING COUNTRIES

GLOBAL CONVENTIONS

1. Convention on Wetlands of International Importance Especially as Waterfowl Habitat (RAMSAR) 1971.
50 contracting parties. Secretariat in IUCN.

2. Convention Concerning the Protection of World Cultural and Natural Heritage (PARIS) 1972.
102 contracting parties. Secretariat part of UNESCO.

3. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (WASHINGTON) 1973.
96 contracting parties. Secretariat part on UNEP.

4. Convention on the Conservation of Migratory Species of Wild Animals (CMS) (BONN) 1979.
24 Contracting parties. Secretariat part of UNEP.

REGIONAL CONVENTIONS

1. African Convention on the Conservation of Nature and Natural Resources (ALGIERS) 1968.

2. Convention on the Conservation of Nature in the South Pacific (APIA) 1976.

3. ASEAN Agreement on the Conservation of Nature and Natural Resources (KUALA LUMPUR) 1985.

In addition there are a large number of Regional Seas Conventions, some of which are relevant to developing countries, and various agreements protecting species, classes etc. e.g. the International Whaling Commission.

these lie in developing countries with little in the way of funds to carry out the tasks, or to prevent encroachment on the sites, the extent of global conservation offered by the convention is greatly weakened. It also implies that the distribution of existing funds between sites is distorted in favour of those that are located in developed countries. For example, the United States and Canada have recently concluded a $1.5

billion Management Plan for North American Waterfowl. It would be surprising if even a fraction of that was spent in total on all wetland habitat protection in Africa.

2.4 Data on what is spent centrally under some of the conventions were not available, although all the relevant bodies were contacted. However, for the major ones the relevant figures are presented in Table 1. These show that the total allocation to central administration and coordination, research etc. for the four major international conventions is $6.3 million a year. This is a small sum by global standards but it covers, of course only a part of what is actually spent in conservation. Figures in the expenditures of the three regional conservation conventions have not been made available but are still being requested.

2.5 Information on what is being spent by the developing countries themselves in support of the conventions is very scarce. It could be collected on a comprehensive basis, but this would require a major research effort and more time than is available for the preparation of this report. Some figures were received from developing countries in response to requests by the author and UNEP, however, indicate that very small amounts are allocated to this area. For example, the government of Chile estimates, that current expenditures on biodiversity conservation are running at around $1.3 million annually. This is about one-sixth of what the government believes should be spent. The Commission of the South Pacific estimates that total spending in the 22 island countries under its mandate was about $500,000 in 1989.

2.6 Some idea of the amounts required for management and protection can also be gathered from occasional studies. In East Africa, for example, IUCN have reported that the annual resources available in the three countries of Kenya, Uganda and Tanzania for administration and protection of wildlife are respectively: $9.6 million (Kenya), $1.1 million (Tanzania) and $96,000 (Uganda). These are small amounts for the enormous tasks that these countries face in this area, particularly in Uganda and

TABLE 1

EXPENDITURES IN DEVELOPING COUNTRIES ON BIOLOGICAL DIVERSITY UNDER MAJOR CONVENTIONS

CONVENTION/ORGANIZATION	ANNUAL BUDGET	ITEMS COVERED AND GENERAL COMMENTS
CONVENTION CONCERNING THE CONSERVATION OF WORLD CULTURAL AND NATURAL HERITAGE	$2,000,000 in 1989	Contributions are through Man & the Biosphere as well as the World Heritage Convention. Very small part of total cost of each site is borne by UNESCO. About half of its exp. comes from its own budget, half from UNDP, UNEP etc.
CONVENTION ON WETLANDS OF INTERNATIONAL IMPORTANCE ESPECIALLY AS WATERFOWL (RAMSAR)	$750,000 in 1988	Expenditure throughout the world runs into "billions" of dollars but small % is spent in LDCs where most of the wetlands are found. Only 61 of 468 listed wetands are in LDCs.
CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS (CMS)	$300,000 in 1989	Funding mainly from UNEP, but now also from parties to the Convention. Figures exclude direct conservation expenditures, which are undertaken by the countries themselves. Budget is mainly allocated to administrative support & coordination.
INTERNATIONAL WHALING COMMISSION	$1,120,000 in 1989	Contributions via contracting governments. Covers research, meetings & coordination.
CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES (CITES)	$3,300,000 in 1989	National government's undertake direct exp. on conservation management & protection. Expenditure by CITES is for research, monitoring, education, training & coordination.

n/a = not available Sources: direct communication with Parties concerned

Notes to Table 1:

The budget in each case refers to expenditures on biodiversity as far as possible.

The following other Conventions were contacted but did not reply:

(a) African Convention on the Conservation on Nature and Natural Resources
(b) Convention on the Conservation of Nature in the South Pacific
(c) Asean Agreement on the Conservation of Nature and Natural Resources

There are several specific agreements that have not been included because they are not directly relevant to developing countries, or because there were no data on them.

Tanzania. By contrast the estimated annual requirements are: $32 million (Kenya), $35 million (Tanzania) and $17 million (Uganda). It is also worth noting, and something that is discussed further later, that the income from the game parks themselves exceed the allocations to the wildlife departments themselves. For example, in Tanzania total earning from wildlife amount to $4.5 million whereas the budget for the department is $1.1 million.

2.7 In general, expenditures on conservation in developing countries are very small. In most of the government budget accounts they do not even rate a mention. Where there are sites that need to be managed, the allocations are generally inadequate. For example, in Nepal, six national parks, five wildlife reserves and one hunting reserve have been declared. In total these parks and reserves cover more than seven percent of the Nepal's land area. Under the National Parks and Wildlife Conservation Act of 1973 no hunting killing or capturing of any wild animal is permitted in the parks or protected areas. Nor is the cutting of trees, grazing or occupying of land permitted. But the capacity of the Department of National Parks and Wildlife Conservation to police the legislation is very limited and violations are frequent. This story is repeated many times in developing countries where intentions to conserve resources cannot be translated into effective action because of a lack of funds. Mobilizing sufficient resources for the purposes of conservation in countries that face severe government budget constraints is one of the key problems that any future convention on global biodiversity must resolve.

2.8 In contrast to the small expenditures on biodiversity conservation in developing countries, the amounts spent in developing countries are relatively large. The following countries furnished information on annual budgets devoted to biodiversity related issues within their countries: Denmark ($45 million, public), Finland ($57 million, public and $30 million private), Luxembourg ($7 million, public). Given the size of these countries, these amounts are very large compared to the allocations in developing countries where the global need is greatest.

2.9 In addition to the activities organized under conventions to protect the environment, a considerable amount is undertaken by national and international organizations. Details of the activities for which expenditure data are available are shown in Table 2. There are obvious gaps in this Table, and many of the figures are not directly comparable. Also there is some danger of double counting as, for example, UNDP expenditures show up in UNDP figures, as well as those of FAO. Nevertheless, after making allowance for such 'double counting' and taking the data as an indication of orders of magnitude, some interesting observations can be made:

(a) the Table shows that international organizations, for which data are fairly complete, spend about $75 million a year on biodiversity related projects. This excludes expenditures on items such as water and soil conservation, but includes, apart from biodiversity as such, plant genetic resources conservation and wildlife management. Even as a fraction of the spending of these institutions on environmental projects alone, this is an almost insignificant amount. The World Bank, for example, lent $2.2 billion in the Latin America and Caribbean region on environmental projects, but nothing on biodiversity as such. The UNDP environmental projects budget was $300 million in 1988. Of that 3%, or $9.4 million, went to biodiversity. The Inter American Development Bank spent nothing in this area and neither did the other major development banks, as far as can be ascertained;

(b) major international spending on biodiversity is undertaken by UN related organizations. In the latest year for which data are available, they spent $41.4 million on the conservation of tropical forest ecosystems. In addition the 9 centres operating under the Consultative Group on International Agricultural Research (CGIAR) and the International Board for Plant Genetic Resources (IPBGR) had a budget of $20-25 million. Finally the Forest Genetic Resources Programme and the Genetic Plant Materials Programme had allocations of under $1 million each;

TABLE 2

EXPENDITURES IN DEVELOPING COUNTRIES ON BIOLOGICAL DIVERSITY

BY NATIONAL GOVERNMENTS AND INTERNATIONAL ORGANIZATIONS

ORGANIZATION/COUNTRY	EXPENDITURE	COMMENTS
1/ US BASED EFFORTS ON BIOLOGICAL DIVERSITY	$37.5 million in 1987.	873 projects in 86 developing countries. Details by region, type of project & source of funding available. Local funds excluded. Also US contributions to multilaterals are excluded.
2/ UNDP ENVIRONMENTAL FUNDING	$9.4 million in 1988.	Total 'environmental' expenditures were around $300 million. Regional breakdown available. Items included in above were: biodiversity $1.593 million; plant resources conservation $5.165 million; wildlife management $2.625 million. This excludes general items such as forest & soil management and TA for environmental support some of which would help biodiversity.
3/ WORLD BANK ENVIRONMENTAL FUNDING	No direct allocation available	Large allocation to 'environment', eg. in Latin America & Carribean alone it was $2.2 billion in 1989. But none was for biodiversity as such. Some water & soil conservation exp. might be relevant. Also World Bank supported FAO Tropical Forestry Conservation - see below for details.
4/ INTER AMERICAN DEVELOPMENT BANK	nil	No identified expenditures on biodiversity as such. Some soil and water conservation might be relevant.
5/ ASIAN DEVELOPMENT BANK	No figures available	Information requested. Some alloaction to FAO is included under FAO Tropical Forestry Conservation.
6/ AFRICAN DEVELOPMENT BANK	No figures available	Information requested. Some alloaction to FAO is included under FAO Tropical Forestry Conservation.
7/ CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH (CGIAR)	$20-25 million in 1988/89	Runing plant genetic resource centers. Integrated Integrated conservation of wild relatives of crop species in situ. Budget comes from donors and UNEP. Covers 9 centers and IPBGR.
8/ FAO/UNEP/UNDP GENETIC PLANT MATERIALS PROGRAMME	< $1 million in 1989.	New international fund for plant genetic resources. Funding from governments and private sources.
9/ FAO/UNEP/UNDP FOREST GENETIC RESOURCES	$680,000 in 1985.	FAO programme with small support from IBPGR funds Danish Govt. and UNDP. Exp. is on seed procurement conservation (ex and in situ) and information.

TABLE 2

EXPENDITURES IN DEVELOPING COUNTRIES ON BIOLOGICAL DIVERSITY
BY NATIONAL GOVERNMENTS AND INTERNATIONAL ORGANIZATIONS

ORGANIZATION/COUNTRY	EXPENDITURE	COMMENTS
10/INTERNATIONAL ORGANIZATIONS VIA FAO CONSERVATION OF TROPICAL FOREST ECOSYSTEMS	$41.4 million in 1986.	Funding is as follows: $23 million country donors; $7.5 million development banks, of which World Bank was $7.2 million; and $11 million UN organizations.
11/INTERNATIONAL TROPICAL TIMBER ORGANIZATION (ITTO)	$200,000 in 1989	TA, approved field projects and consultancies. Voluntary contributions. Budget of $200,000 concerned with biodiversity is 5% of total.
12/COMMONWEALTH SECRETARIAT	$120,000 on average p.a. 1984-89	Conservation of plant resources, habitat protection and training in commonwealth countries.

Sources:

1/ "A Survey of US Based Efforts to Research and Conserve Biological Diversity", World Resources Institute, 1989.
2/ "Funding and Coordination of Environmental and Resource Management Projects by Major Donor Agencies and International Lending Institutions", R.M. Field UNEP, 1990.
3/ See 2/ above and World Bank Annual Report, 1989.
4/ See 2/ above.
5/ Annual Report, 1989.
6/ Annual Report, 1988.
7/ Annual Report, 1988 and Direct Communication
8/ "Commission on Plant Genetic Resources", Third Session, FAO, April 1990.
9/ "Sixth Session of the FAO Panel of Experts on Forest Gene Resources", FAO, December 1985.
10/ "Committee on Forest Development in the Tropics: International Cooperation in Tropical Forestry", Eighth Session, FAO, 1987.
11/ Personal Communication from ITTO, 1990.
12/ Personal Communication from Commonwealth Secretariat, 1990.

Notes: In addition FAO has estimated that its average annual expenditure on biodiversity conservation and use over the ten years 1980-89 has been about $28 million. Of this $3 million came from its regular programme and $24 million from extra bugetary resources (UNEP/UNDP etc.)

(c) the only country for which comprehensive data on spending on biodiversity are available is the United States. In a recent study, it was estimated that total spending, outside of US allocations to multilateral sources, on biodiversity in developing countries was $37.5 million in 1987. This is a large amount compared to the total spent by international organizations, and breaks down as shown in the box below. Although more than half of the total is spent by the government, NGOs and foundations are responsible for the other half. Over half of the total goes to the LAC region, with Costa Rica alone accounting for 15% of the total. Finally in terms of projects supported, research is the most important, followed by site/species management and education.

(d) detailed figures are not available for other countries but it is known that the Nordic group contributes significantly to aid in this area. For example, it has recently established a gene bank in South Asia which is worth $20 million over the next 20 years.

(e) a similar breakdown for the expenditures of the international organizations is available for biodiversity. UNDP environmental funding is concentrated more on Asia and the Pacific (32%) and Africa (25%). The FAO's tropical forest ecosystem conservation expenditures are supported by most OECD countries, with nearly half of the direct funding coming from the US. In overall terms, expenditure on tropical forestry by the FAO breaks down thus: Africa: 47%, Asia and the Pacific (33%) and Latin America and the Caribbean (13%). A further 6% is spent on global programmes. The IBPGR supports the collection of crop plant species, their evaluation, training and research throughout the world. The same applies to the Forest Gene Resources programme and the new International Fund for Plant Genetic Resources.

2.10 This section has shown that expenditure on biodiversity in developing countries is probably very low, both from domestic and external resources. The total allocation from external sources to these countries cannot be estimated, but the major contributors (the international

BIODIVERSITY SPENDING BY THE USA IN DEVELOPING COUNTRIES

By Source of Funding:
Govt.: 53% NGO:24% Other:23%

By Region(*):
Africa:12% Asia:16% LAC:60%

By Area:

Research	:44%	Site/Species Management:	23%
Education	:15%	Policy Planning :	6%
Institutional Support	:12%	Other :	1%

* 11% of funding is multiregional
LAC = Latin America & Caribbean

Source: World Resources Institute.

institutions and the US) between them account for around $112 million a year. Even if it is assumed that other OECD countries provide bilaterally an amount in proportion to their contribution of total bilateral aid, this figure would only rise to $191. To this can be added the expenditures of the Conventions' secretariats, which amount to $6 million for the four main conventions. All this is a small fraction of what is spent on conservation in developed nations and there are several reasons for thinking it is inadequate for the tasks faced by these countries. In the next section the main areas where additional funds are needed are analyzed, and an estimate made of the amounts that might be required to achieve the goals of biodiversity conservation that many have expressed, through the texts of the various conventions, as well as through more general statements on sustainable development.

III UNMET NEEDS FOR BIODIVERSITY CONSERVATION

3.1 In examining the unmet needs for biodiversity conservation, the following questions need to be addressed:

(a) what are the main categories in which current efforts are insufficient and to what extent are they insufficient;
(b) what are the best means of mobilizing the required additional resources, both domestic and international; and
(c) what role, does an international convention on global biodiversity have to play?

The first two of these are dealt with in this section. The third is examined in the final section.

3.2 As has been observed in the previous section, considerable efforts are already being made to protect the biodiversity of the planet. There are several conventions concerned with the issues; and the efforts of bilateral and multilateral donors and NGOs are not without substance. However, the strong conclusion from the review of existing efforts in this field is that: (a) it is not enough to cope with the magnitude of the problem, (b) developing countries, in which the bulk of the effort in biodiversity conservation should be made, are precisely the ones with the least resources to make the requisite efforts and, therefore, (c) financial mechanisms have to be put into place to mobilize more resources for these countries.

3.3 In a recent Report of the Ad Hoc Working Group of Experts on Biological Diversity[8], the following areas were identified as requiring further funding:

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[8] Report of the Ad Hoc Working Group on the Work of its Second Session in Preparation for a Legal Instrument on Biological Diversity of the Planet, UNEP/Bio.Div.2/3, February 1990.

(a) surveys, inventories and identification of biological diversity rich areas;
(b) development of technologies related to the conservation and sustainable use of biological diversity;
(c) technical assistance for research, training, education, public awareness etc;
(d) management strategies and plans for biological diversity rich areas, including recovery plans, coordination of various conservation activities and development of national conservation strategies;
(e) regular monitoring of the status of the world biological diversity;
(f) coordination of conservation strategies with policies for sustainable economic development;
(g) priority conservation projects; and
(h) transfer of technology.

In the remainder of this section, each of these areas is considered with regard to: why the current effort is inadequate, what kinds of action are required and how they might be funded.

Surveys, Inventories and Identification of Biological Diversity Rich Areas

3.4 As was noted earlier, the extent of our knowledge of the biodiversity of the planet is very incomplete, certainly less than 25% and perhaps only as much as 5%. Traditionally, inventory work has been carried out by a small group of highly skilled analysts and their labours have been painstaking, slow and expensive. According to one estimate, it would cost around $330 million just to survey 10% more of the plant and other species. It would cost ten times that to conduct complete habitat surveys and ten time that again to conduct complete genetic surveys. Such costs are prohibitive and unrealistic from both a physical and financial resource point of view. Moreover they do not allow for the trade-off between conservation and surveying. Presumably if species loss could be slowed down, the time period over which the surveying took place could be that much longer.

3.5 It is worth noting, however, that recent experience in Costa Rica has resulted in innovative approaches being adopted for this work. Local rural residents have been trained by scientists to collect and mount large numbers of hitherto unstudied insects and to key them at the macro level for subsequent systematic analysis. This kind of activity requires a mixture of local and foreign resources, and the total additional effort that is manageable could run into some millions of dollars. It has been argued, with some justification that the funding for this should come, in part, from those who benefit from the commercial development and use of biological products. In particular, a tax on the royalties from patented biological materials and a surcharge on tropical timber imports could be used to support survey and inventory work, as well as other activities related to site management, discussed in more detail below[9]. Combining the use of low cost survey methods, and some support from taxes of the kind described above could offer a start to meeting the financing need in this area. This could be further supported by funds from central governments, but the amounts of these would need further investigation.

Development of Technologies Related to the Conservation and Sustainable Use of Biological Diversity

3.6 The role of biotechnology is of importance in this regard. Biotechnology will lead to new and improved methods of conservation of genetic resources and accelerate the evaluation of germplasm collections for specific traits. It is argued therefore that there is a need to promote biotechnology that has the potential to benefit biological diversity and, more generally, that addresses more effectively the problems of sustainable development in developing countries. Fortunately there is again an appropriate source of funds for this purpose; namely the enterprises that profit from the commercial uses of biotechnology[10]. It

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[9] A tax of 3-5% on tropical timber imports has been proposed by the IUCN/WWF/UNEP "World Conservation Strategy for the 1990s", 1989.

[10] This is also an area where there is a need for a global convention (see below Section IV).

is not possible to estimate what amount should be transferred; that would depend on how successful such support programmes were and that is extremely difficult to gauge at this stage. However, it should be possible to start a programme initially with a relatively modest budget.

Technical Assistance for Research, Training, Education, Public Awareness

3.7 Training is undoubtedly one of the main areas where additional support is needed, primarily from external sources. Some of the activities have already been described above (see Section 3.4). In addition, those responsible for current programmes, such as the IPBGR, have repeatedly pointed to the need to expand the cadre of trained personnel in developing countries in the fields of conservation and biodiversity. For example, IPBGR have indicated that what is needed in their field is training for at least 300-400 individuals to MSc and PhD levels spread over 60 countries. Funding for this kind of activity can come in part from the resources raised by innovative methods such as taxes on the commercial development of biological diversity, but will probably need to be supplemented by direct funds for additional training. Furthermore the need in this area is urgent and cannot wait for the 'new' proposals to be put into force. Even the modest programme proposed by IPBGR would involve a cost around $10 million a year for the next 2-3 years. A more ambitious programme such as the one recently proposed by Mcneeley et al. indicates the need for 7500 more taxonomists. Training these over 10 years would cost around $22 million a year.

Management Strategies and Plans for Biological Diversity Rich Areas, Including Recovery Plans, Coordination of Various Conservation Activities and Development of National Conservation Strategies

3.8 This group covers a number of categories of expenditure. First there is need to increase funding for the management of protected areas and areas that need to be protected. Existing resources are inadequate for this purpose in most developing countries (see Section II above). However, more funds can be mobilized from exploiting the commercial values of these sites, many of which are of outstanding natural beauty and for

which visitors are willing to pay, and many of which have products that can be harvested on a sustainable basis. Already 'eco-tourism' revenues to some developing countries are substantial and these could be expanded by a combination of 'tourism taxes' and carefully managed growth in tourism itself[11]. Much of this will help conserve the resources in their own right, but the cause of biodiversity will benefit even more if some of the profits and tax revenues can actually be allocated to conservation. With tourism and related taxes this requires hypothecation, or earmarking, which in turn requires the agreement of the government concerned. Similar considerations apply to park fees, hunting permits etc.

3.9 External support for site management can also be provided through mechanisms such as debt for nature swaps. In these arrangements, the debt of a country is acquired at a substantial discount on the secondary market, by an NGO in a developed country, and the servicing obligations then paid into a fund that finances conservation programmes. So far five countries (Bolivia, Costa Rica, Ecuador, Madagascar and Philippines) have participated in debt for nature swaps, reducing their external debt by about $100 million. This makes little impact on the total indebtedness but a big one on the conservation budget. For such swaps to play a bigger role, the debtor governments need to be willing to accept them more readily, and competent local NGOs need to be formed, to manage the endowment and conservation programmes. In some cases, however, there is an identified need for the sites to be internationally managed without recourse to any swaps. In such cases additional funds may be required from external sources.

3.10 The other two activities under this category require different forms of support. Coordination is essentially the activity of an international body, probably under the aegis of a convention, and is discussed in the next section. The formation of National Conservation Strategies is

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[11] See, for example, J. Gradwohl and R. Greenberg, [1988], Saving the Tropical Forests, Earthscan, London.

already taking place under the direction of the IUCN and this work could be expanded. Funding would have to come from the usual sources: foundations, NGOs and bilateral aid agencies.

Regular Monitoring of the Status of the World Biological Diversity

3.11 This is an important activity that needs to be undertaken, bringing together what is already being done, particularly by bodies such as IUCN, and commissioning studies to fill the gaps as necessary. It would be appropriate for it to be undertaken by an international body responsible for biological diversity. An annual budget for such activity would probably need to be in the region of $2 million. This would permit a certain amount of primary data collection and the synthesis of what is already collected.

Coordination of Conservation Strategies with Policies for Sustainable Economic Development

3.12 It is important to emphasize that conservation is not a goal in its own right, but an objective with the purpose of improving living standards throughout the world and particularly in developing countries. Furthermore, the task of conservation is rendered much easier if those who have access to the resources also have an incentive in conserving them, if those responsible for managing national budgets do not see conservation as a drain on their limited funds, and if government policies themselves are not designed to destroy biodiversity through perverse inducements. Usually, though not always, these incentives are economic. The task that is being faced, is to indicate how such policies and incentives might be structured, and to help developing countries in implementing them. To some extent that is what the National Conservation Strategies set out to do with the help of IUCN. However, one of their weaknesses has been the relative neglect of the 'economic dimension'. To strengthen this would require linking the conservation strategies to the macroeconomic plans of the country. Technical assistance in this area would be of great benefit and could be provided through UNDP.

Priority Conservation Projects

3.13 Priority conservation projects are an important area for future funding. There are some sites and species where, unless emergency action is taken, habitats are threatened and extinction is a real possibility. One of the tasks of any putative organisation dealing with biodiversity would be to identify those areas and species which could draw on a special fund. Such a facility has been identified as being important in the various discussions of the Working Groups, and others. It is facility that would have to be operated through one of the existing institutions dealing with biodiversity, but under the control of the members of nay organization responsible for the overall global convention on biodiversity. The sums involved in its efforts are hard to quantify at this stage. Much the best policy would be to start with a small allocation and see how successfully it was used up.

Transfer of Technology

3.14 Finally there is the transfer of technology. New methods of conservation, and products developed through biotechnology can help the process of conservation. Those undertaking the development would have to be compensated if they were to give access to their technology to the developing countries. This would require funds from a central source. At the same time, the benefits of the commercial exploitation of products should be more equitably shared between those concerned with research and development, the plant breeders and the owners of genetic resources. The FAO Commission on Plant Genetic Resources addresses some of these issues. Another possibility is to give suppliers of genetic resources preferential treatment to the products obtained from gene banks established with international funds.

3.15 To date no proper appraisal of the items that might be transferred, and the costs involved, has been undertaken. Such an evaluation must be a precursor to any comprehensive programme of technology transfer. At this stage it is not possible to say how large the fund would be, or what kinds of items it would deal with.

IV A CONVENTION FOR BIODIVERSITY

4.1 In this final section the reasons for a new convention on biodiversity are examined and the issue of what its terms of reference should be is addressed. First there is a need for a global strategy on biodiversity, covering all aspects of the problem, and identifying priorities in certain areas and in certain fields. That can only be achieved through an international agreement.

4.2 Second, although existing conventions cover many conservation issues, there are still gaps that need to be filled, two of which stand out. First, present conventions address specific issues but not the whole area of biodiversity as such. Hence there is no facility for monitoring and evaluating the progress, or lack of, that is taking place in this domain. Second, and most importantly, they do not concern themselves with the transfer of resources and support for biodiversity conservation in developing countries. Some link between the stated objectives of conservation and the commitment of parties to support conservation in a global context is required.

4.3 It is essential, of course, that any new convention take account of the existing conventions and the activities that they support and not duplicate them. The treaty needs to ensure:

(a) that the benefits of biodiversity protection are reflected in the policies of the member countries that impinge on biodiversity;
(b) that it involves itself with issues of international transfers of revenues from taxes on products derived from the commercial development of biodiversity in developed countries. The framework within which such taxes would be levied would be a matter of concern for the convention;
(c) finally it needs to act as a facilitator for the private sector in developed countries to transfer its technology to the relevant institutions and individuals in the developing countries.

4.4 One question addressed at the beginning of this report was to do with the size of the fund required to achieve the unmet conservation needs of developing countries. One estimate provided by the World resources Institute refers to the unmet needs of conservation being of the order of $2-5 billion per annum over the next decade. Such a figure is not of much use in the context of this exercise, because it does not identify which expenditures are covered, how much can be raised from domestic sources, including new ones, and how much can be left to the private sector. What is more important than an overall 'figure' (which is of interest in its own right) is an identification of the sources and uses of the various resources. This report has tried to carry out that task. A number of features stand out in this regard. Many of the required resources do not need to be raised from a central fund, but to be mobilised from a more effective commercial (but sustainable) exploitation of the habitats and species in the developing countries. This includes tourism, use of forest products, and wildlife. However, additional resources will be needed from a central fund, to which member countries should subscribe on concessional terms. This would be channeled through existing institutions such as FAO, UNEP, UNDP and the Development Banks and would cover: support for training, priority management of sites and species, transfer of technology in appropriate areas and monitoring of global changes in biodiversity. From the analysis in this report it would seem that such a fund is more likely to be 'supply constrained' rather than constrained by the demands for further work in this area. Limiting factors will be: the capacity of developing countries to undertake and organise the relevant work, and the perceived benefits of individual parts of the programme to those who stand to gain from it in a direct way. In the light of these considerations, it is unlikely that the fund could be very large; certainly not in the first instance of the order of billions of dollars as stated in the recent World Resources Institute report.

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